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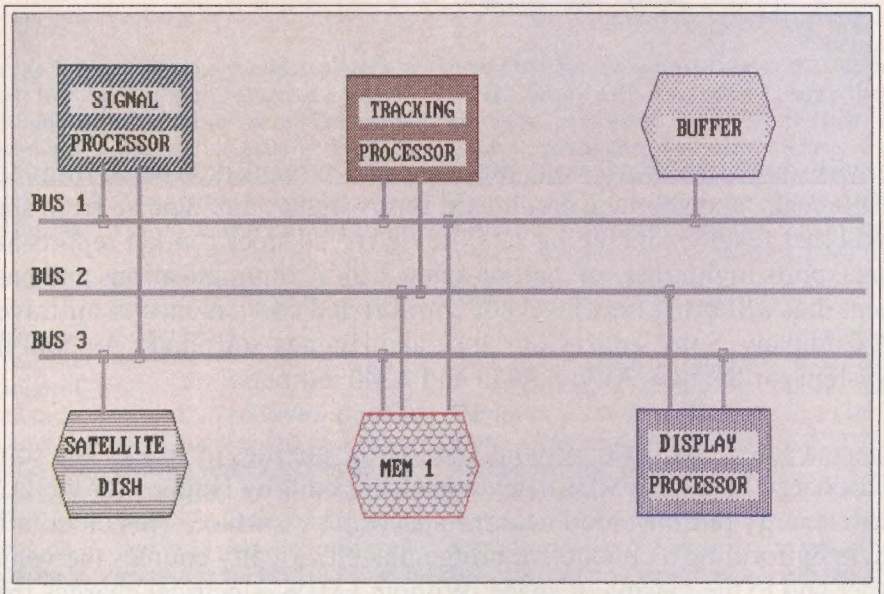
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Airline passengers will soon view movies on personal video screens directly in front of them, make phone calls from their seats, and shop via credit card for in-flight merchandise from shopping channels. These and other features, including satellite-delivered stock market reports and up-to-the-minute news and sports highlights, are part of a new cabin communications and passenger entertainment system that will bring new levels of comfort and convenience to air travel. A team of Hughes Aircraft Company, Sony Trans Com Inc., and Hughes-subsidiary Avicom International is developing the system for the new Airbus A330 and A340 jetliners.

A self-contained plasma source will help prolong the life of satellites in space. The source, part of the Flight Model Discharge System (FMDS), developed and built by Hughes for the U.S. Air Force, produces a dilute low-energy plasma cloud near the spacecraft's surface. This cloud effectively "grounds" the vehicle by forming a conductive bridge that electrically couples the vehicle's outer surfaces to each other and to the plasma of space. Without FMDS, electrical charges from ionized gases could build up on the spacecraft, causing arcing that could damage delicate electronic equipment.

An improved flow of information between air defense command and control centers and surface-to-air missile systems will be one result of a new state-of-the-art communications link being designed by Hughes. The link, called the Intelligent Interface Processor, will provide the signal interface between AN/TSQ-73 surface-to-air missile control systems and fixed NATO Air Defense Ground Environment sites in West Germany, Italy, Belgium, and the Netherlands. With the new system, NATO commanders will be able to allocate targets to be engaged by missile batteries and still retain autonomy. Commanders will also be able to exchange target and status information currently available only through voice communications.

U.S. Military aircraft crews will now be protected against laser threats. Together with the U.S. Army, Hughes Danbury Optical Systems, a Hughes subsidiary, has developed a warning system for U.S. helicopter crews subjected to laser threats. The AN/AVR-2 Laser Detecting Set (LDS) detects, identifies and characterizes optical signals 360-degrees around the aircraft. Interfacing with a Radar Signal Detection Set, the system also functions as an integrated radar and laser warning receiver system. The Army and Marine Corps have successfully completed testing and initiated production of this laser detecting system, which will soon be standard equipment on their combat helicopters.

Three-quarters of a billion dollars are on the way. And in 1990, Hughes Aircraft Company's Ground Systems Group is anticipating many more new contracts, in Air Traffic Control (ATC), Air Defense, and the commerical sector. These new programs have created excellent career opportunities for experienced and motivated individuals in systems engineering, software engineering, and test engineering. Appropriate background for work in the defense and intelligence communities is preferred in some positions. For immediate consideration, please send your resume to Hughes Aircraft Company, Ground Systems Group, Dept. 1343-T, PO Box 4275, Fullerton, CA 91634. Equal Opportunity Employer. Proof of U.S. citizenship may be required.

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HUGHES

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NEWSLOG

NOV 11: After 42 years as Argentina's nationalized telephone company, the **Empresa Nacional de Telecommunicaciones (Entel)** was returned to private ownership, with European and U.S. investors buying 60 percent of it.

NOV 13: The **British Government** said it would pursue wide-ranging deregulation of the nation's telecommunications industry. The move is likely to influence policy in other countries and will include allowing largely unrestricted access to the local, long-distance, and international service markets, and erasing legal restraints separating the telephone and cable TV industries.

NOV 17: Supported by the **Department of Energy,** scientists at **Sandia National Laboratories,** Albuquerque, N.M., and the **University of Wisconsin in Madison** said they have built the world's first superconducting transistor able to operate at relatively high temperatures. Employing a superconducting film of thallium and copper oxide, the device could mean much faster computers.

NOV 20: Japan's **Ministry for International Trade and Industry (MITI)** said it would delay and dilute proposals for a US $1 billion Japanese-led multinational collaborative research program into intelligent manufacturing systems, or computer-integrated factory automation. The agreement addressed U.S. and European Community fears of a one-way flow of technology from the West into Japan. The three trade partners agreed instead to start a one-year feasibility study to cover funding, choice of research areas, and intellectual property rights.

NOV 20: **Italtel**, the Italian state-controlled telecommunications maker in Milan, said it would start producing its Linea U2 digital switching system in Leningrad and Abkhazia, Georgia, beginning in 1992. Italtel will provide **Krasnayya Zarya (Red Dawn)**, the largest USSR telecommunications maker, with an eventual annual production of 1.5 million lines, about 25 percent of the Soviet market.

NOV 21: The **British Government** began selling off its electrical utilities—12 regional companies in England and Wales—in its largest privatization in 10 years and said it expects to make US $10.2 billion in the stock offering. At least 34 percent of the 2.16 billion shares, to be sold for 240 pence (US $4.73) each, would be reserved for the British public.

NOV 27: The **U.S. Department of Energy** dedicated a US $1.3 million plant at the Savannah River Site, Aiken, S.C., to clean up the nation's most hazardous wastes after 40 years of atomic bomb making. The largest in the nation, the plant will be tested for two years with nonradioactive wastes and will begin operating in 1992. The material now in decaying steel tanks will be encased in logs of strong glass and wrapped in steel.

NOV 27: A six-member Federal study panel, headed by Lew Allen Jr., director of the Jet Propulsion Laboratory, Pasadena, Calif., said the serious defect in the main mirror of the **Hubble Space Telescope** went undetected because of flawed management procedures and communications at NASA and Perkin-Elmer Corp., Norwalk, Conn., which manufactured the mirror in the early 1980s.

NOV 27: Ten personal computer manufacturers led by **Tandy Corp.**, Fort Worth, Texas, said that, with the drop in cost of equipment needed to do multimedia programs, they would begin delivering PCs specially configured to run those programs. Simultaneously, **Microsoft Corp.**, Redmond, Wash., said it would make available software tools to allow developers to create programs using multimedia.

NOV 29: Europe's semiconductor research project, the **Joint European Submicron Silicon group (Jessi)**, admitted **IBM Europe SA**, near Paris, the first U.S. company allowed to join the group. Jessi also agreed to formalize its ties to **Sematech Inc.**, the Austin, Texas-based semiconductor manufacturing consortium.

NOV 30: The **International Frequency Registration Board,** in Geneva, Switzerland, which oversees the allocation of orbiting positions for communications satellites, told the tiny South Pacific nation of Tonga that it must amend its October claims to 16 unused satellite positions over the Pacific. The board said **Tonga** must, by Jan. 1, pick no more than six slots, announce specific plans for them and cancel the rest of its claims.

DEC 1: British and French workers connected the smallest of three 31-mile (50-kilometer) tunnels being built under the **English Channel** to link Britain to the European Continent. The tunnel serves two larger ones, through which trains will zip—carrying people, cars, trucks, and freight—after the project is completed in 1993.

DEC 2: The space shuttle **Columbia** was launched from Cape Canaveral, Fla., completing the return to service of all three U.S. shuttles and ending six months of delays caused by fuel leaks and mechanical troubles. Even then, telescope and plumbing problems hampered its mission to operate the Astro observatory.

DEC 2: **Toyohiro Akiyama** became the first journalist and the first Japanese ever sent into space, traveling on board a Soviet Soyuz TM-11 rocket launched at the Baikonur Cosmodrome in Kazakhstan. The US $12 million trip was sponsored by several Japanese companies, including the Tokyo Broadcasting System. That financing enabled the Soviets to get two of their astronauts up to the Mir-2 space station.

DEC 5: **AT&T Co.** announced a hostile cash tender for **NCR Corp.**, Dayton, Ohio, after its US $6 billion offer was re buffed by the computer maker.

DEC 5: High-definition television sets, with 36-inch digonal screens, manufactured by **Sony Corp., Matsushita Electric Industrial Co.**, and **Hitachi Ltd.**, went on sale in Japan for as much as US $34 000 each. Analysts said that should fall to $7500 in five years.

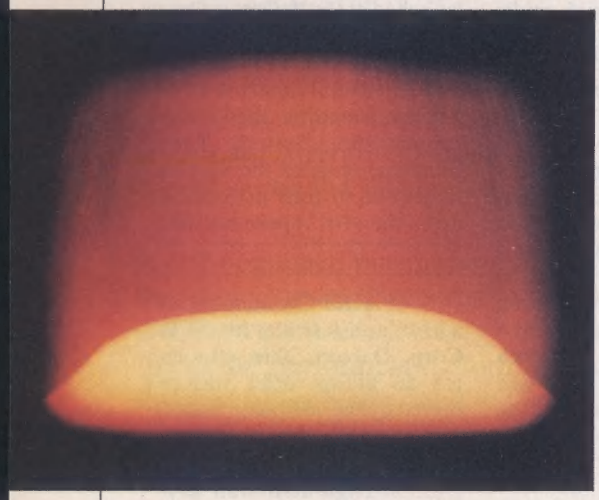
DEC 10: A 12-member panel of academic and industry leaders—asked by Vice President Dan Quayle, head of the National Space Council, to study the future of the U.S. space program—issued a report recommending a dramatic refocusing of **NASA's space efforts,** including ceasing to rely on its fleet of space shuttles by building an unmanned rocket booster, redesigning and simplifying the proposed space station, and making shifts in management priorities.

Preview:

JAN 15: Today starts a three-day conference on the "Challenges in Aviation Human Factors: The National Plan," cosponsored by **NASA**, the **Federal Aviation Administration,** and the **Human Factors Society**, Santa Monica, Calif. The meeting is being held at the Sheraton-Premiere Hotel, Tysons Corner, Vienna, Va.

Coordinator: Sally Cahur

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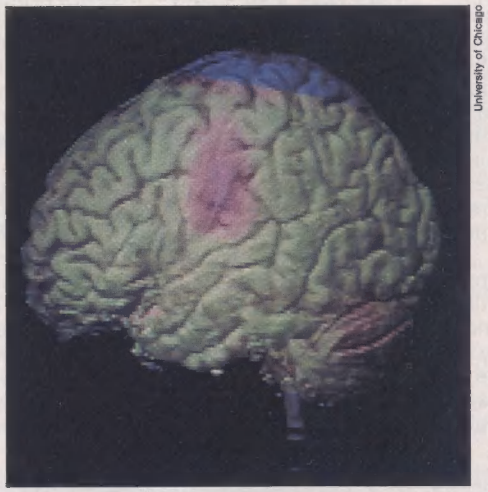
Cover: Photograph of the star cluster R 136, taken by a camera aboard the Hubble Space Telescope last July, reveals individual young stars not visible from earth-based telescopes. This image was computer processed to remove the blurriness introduced by the spherical aberration of the space telescope's main mirror. The star cluster R 136 is 170 000 light years away, in the center of the 30 Doradus gaseous nebula in the Large Magellanic Cloud, one of the Milky Way's two companion galaxies. North is to the left. *See p. 31.* *Photo: NASA*

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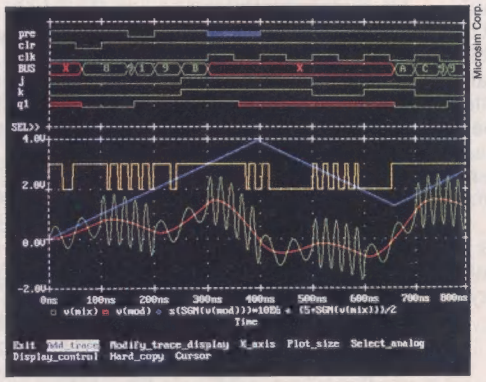
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Layers of ability

The major league baseball system in the United States has an interesting personnel policy called free agency. After fulfilling a contract of several years' duration with one team, a baseball player can turn free agent. His services then become the subject of a well-publicized auction among the various competing teams. Subsequently, even the most mediocre free agents sign for annual salaries in the millions of dollars.

Watching some of these wealthy ex-free agents playing baseball on television fills me with a jealous anguish. They may not be able to field or hit, but they can drive to the stadium in a Rolls Royce, whereas I, a reasonably accomplished engineer, have trouble keeping my old clunker in repair. Where is the justice?, I ask.

In my fantasies I imagine a free agency system for engineers. When your contract expires with Acme Engineering, you turn free agent and offer your talents to the highest bidder. But, alas, even in my fantasy the million-dollar deals fail to materialize. The range of offers that any of us received would be quite narrow, with the awful possibility that our measly present salary would be at the upper end of the scale. This brief and shattering vision leaves me with the question of why mediocre baseball players are paid so much and the most talented engineers paid so little, relatively speaking.

Simple, you say. Supply and demand. There is a great demand for entertainment and a supply of only a few hundred baseball players at the major league level, whereas there are millions of engineers, all engineering at a more or less equivalent level. In the case of baseball, perhaps 50 million young boys (and girls) learn the game and aspire to stardom. Of that multitude, only about 0.001 percent make it to the major league level where they are able to earn their livelihood playing baseball. If we draw a curve of salary vs. percentile, there is zero salary for the first 99.999 percent of the relevant population. Of course, the last thousandth of a percent does very well. The curve is simply an impulse function at the right edge of the paper.

In engineering, by contrast, there is a much smaller pool of aspirants. (Too small, some would say, but that is another story.) Of those who enter engineering school, perhaps half actually become graduate engineers. The curve of salary vs. percentile is quite flat, with the best-paid engineers earning perhaps four times the salary of beginners. (We exclude those wealthy aberrations who have left engineering for other occupations.) The good news is that there are jobs for everyone. The bad news is that there is so small a spread in salary that there may be little to which we might aspire. We have no major league, no free agents, and, quite possibly, no stars.

I wonder if the range of abilities among engineers reflects the small range of salaries. Is the best engineer only a little better than average, but a major league baseball player—however mediocre—almost infinitely better than the average amateur?

Some light on the latter part of this question was shed by a recent experience of an engineer friend. This engineer happens to be the best tennis player I know, having achieved the No. 1 ranking in the company's tennis ladder. One day not long ago he found himself with a free afternoon at a resort hotel in a foreign country. Since he takes his tennis racket with him wherever he goes, he put up a little notice on the hotel's bulletin board. "Advanced player looking for tennis match . . .," he wrote, adding his name and room number.



Cathy Wassylenko

Shortly thereafter he received a call about his notice. "I am _____," said the caller, giving a name familiar to us all as that of an aging but highly ranked tennis professional. He, too, was looking for a match that afternoon. "I didn't really mean 'advanced,' " stammered my friend. But in spite of his protestations of hapless mediocrity, the match was arranged—a match surely taken right out of our best Walter Mitty fantasies.

"How did it go?," I asked in eager anticipation. I could see myself out there, hacking away at the pro. I wondered how I would do. I mean, how good are they, really? With a small wave of his hand my friend deprecated the whole affair. What I had already heard was the best part. He said that he had played the match of his life, putting everything he had into every stroke, while the aging pro had paid little attention, sipping cocktails between points, and flirting with his courtside girlfriend. "So how did it go?" I persisted. "We played one set," he finally answered, "and I didn't get a single point."

I tend to classify activities based on the number of levels of skill that exist, where I think of a layer being distinguished by the ability of an average member of that layer to completely suppress someone from the layer below—consistently 6-0 in tennis, say. Perhaps there are six or seven layers in tennis, at a guess. How many layers are there between me and, say, Michael Jordan in basketball? Or between me and Karpov in chess, or Isaac Stern on the violin? Many, I am afraid—layers upon layers of ability. I remember a few years ago shooting a basketball in my driveway and making three or four dozen free throws consecutively. I was proud of myself, and out of curiosity checked the *Guinness Book of Records*. My pride quickly vanished in embarrassment; the record was somewhere in the thousands! You name it, somewhere in the world there are people who are unbelievably good at whatever it is.

Are there so many levels of ability in our profession of engineering? Perhaps—but perhaps not. The field itself is evolving at an incredible rate, and we all find ourselves riding the roller-coaster crest of a tidal wave of change. Some of us are swept under, and the rest of us swirl about in the foam, with our eyes fixed on the rocks below. I look ahead for the leading swimmers, the stars who are levels ahead of the pack, and I see an empty ocean. I look back for the laggards who have missed the waves and are merely bobbing about in a becalmed sea, and though I see some, that is not where the masses are. Most engineers are clustered on those crashing waves. I see competence, and even brilliance, wherever I go in our profession. I see it in individual engineers in small companies, in the large corporations, in government, and in academia. I am often amazed to find state-of-the-art engineering ability in the most out-of-the-way places.

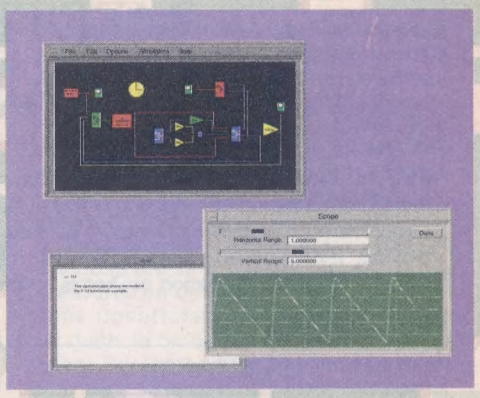
It makes me proud to be a member of such a group. There is always room at the top, but the bottom is never far away either. Maybe we don't have stars who are levels ahead, and maybe we couldn't turn free agent, but I feel privileged to be one of such an outstanding company.

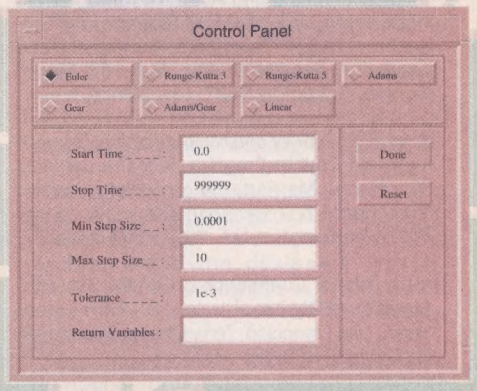
—Robert W. Lucky

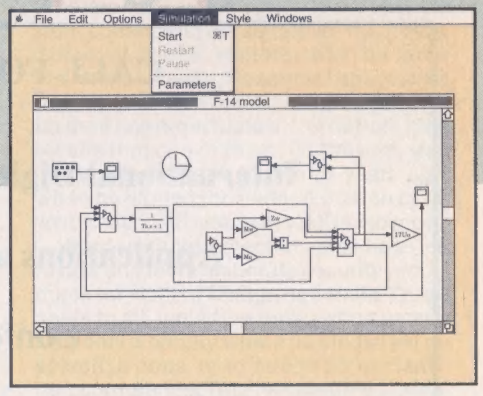
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Annual Reliability and Maintainability Symposium and Exhibits Program (R et al.); Jan. 29-31; Orlando Marriott, Fla.; I.A. Feigenbaum, Vitro Corp., 600 Maryland Ave., S.W., Suite 300W, Washington, D.C. 20024; 202-646-6327.

International Conference on Wafer Scale Integration (COMP et al.); Jan. 29-31; Fairmont Hotel, San Francisco; Terry Chappell, Chappell Enterprises; 408-662-1936.

Workshop on Parallel Distributed Simulation (COMP); Jan. 21-23, Disneyland Hotel, Anaheim, Calif.; IEEE Computer Society, Conference Services, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013.

FEBRUARY

Power Engineering Society Winter Meeting (PE et al.); Feb. 3-7; Penta Hotel, New York City; J. G. Derse, 704 Timber Brook Dr., Bedminster, N.J. 07921; 908-658-4042.

Semiconductor Temperature and Thermal Management Symposium-SEMI-THERM (CHMT); Feb. 12-14; Sunburst Hotel, Scottsdale, Ariz.; C/S Communications, Box 23899, Tempe, Ariz. 85285-3899; 602-967-7444.

International Solid State Circuits Conference (ISSCC et al.); Feb. 13-15; San Francisco Hilton, San Francisco; Diane Suiters, Courtesy Associates, 655 15th St., N.W., Suite 300, Washington, D.C. 20005; 202-639-4255.

Optical Fiber Communication Conference (COM, LEO, et al.); Feb. 17-22; The Convention Center, San Diego, Calif.; OFC Conference Management, Optical Society of America, 2010 Massachusetts Ave., N.W., Washington, D.C. 20036; 202-223-0920 or 202-416-1950.

11th Nonvolatile Semiconductor Memory Workshop (ED); Feb. 19-22; Hyatt Regency Hotel, Monterey, Calif; Theodore Dellin, Sandia National Laboratories, Division 2146, Box 5800, Albuquerque, N.M. 87185; 505-844-2044.

Seventh International Conference on Artificial Intelligence Applications-CAIA 91 (COMP et al.); Feb. 24-28; Fontainebleau Hilton, Miami Beach, Fla.; IEEE Computer Society, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013.

Computer Society Conference-COMPCON Spring '91 (COMP); Feb. 25-March 1; Cathedral Hill Hotel, San Francisco; COMPCON Spring '91, IEEE Computer Society, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013.

MARCH

Fifth International Workshop on High-Level Synthesis-HLSW (COMP et al.); March 3-6; Bülerhohe, Germany; Raul Campusano, IBM Thomas J. Watson Research Center, Box 218, Yorktown Heights, N.Y. 10598; 914-945-3871.

Electronics and Instrumentation Conference and Exhibit (ISA/IEEE); March 6-7; Cincinnati Convention Center, Ohio; O.M. Melnyk, IEEE, Box 15044, Cincinnati, Ohio 45215; 513-397-1044.

Applied Power Electronics Conference and Exposition-APECT '91 (IA, PEL); March 11-15; Hyatt Regency Dallas, Dallas; Ann Beightol, Courtesy Associates, 655 15th St., N.W., Suite 300, Washington, D.C. 20005; 202-347-5900.

International Conference on Microelectronic Test Structures (ED); March 18-20; Kyoto Grand Hotel, Kyoto, Japan; Noriaki Nakayama, (81+462) 48 3111, ext. 3730.

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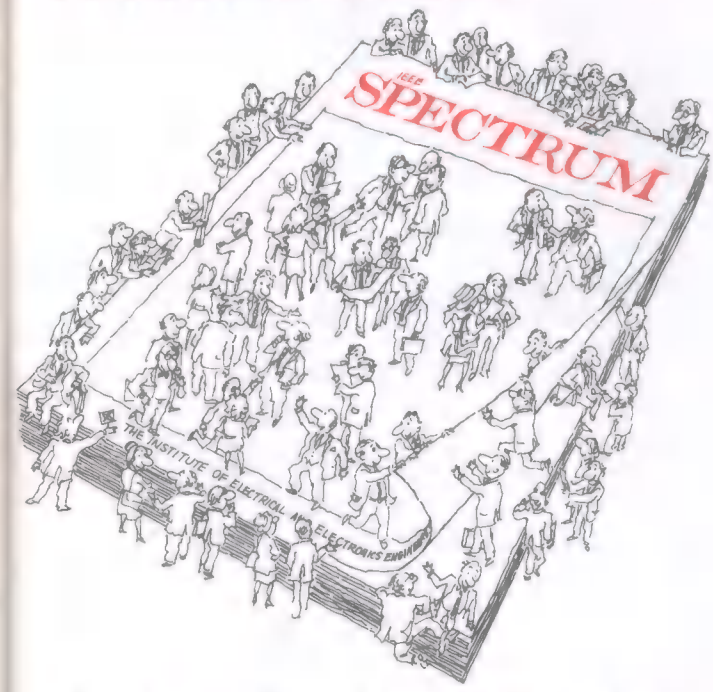
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Worries about potential spies have led to new and more elaborate security procedures for visiting foreign nationals. These apply to all, including those who come to visit only facility where no classified research is done, or to attend an unclassified conference. This has created a problem in the section of Los Alamos where I regularly work, which is unclassified and staffed mostly by visiting university researchers such as myself. Some groups hoping to visit the laboratory have found it so difficult to secure permission, even when they have already been scheduled to do their work, that they have elected to pursue their research elsewhere.

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Overall, though, her book is fascinating insight into some of the feelings and problems of those who work directly with the technology that poses one of the major threats to humankind. Though the Cold

(Continued on p. 14)

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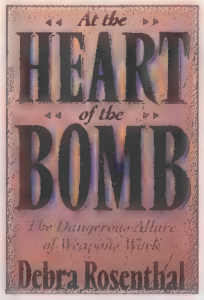
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At the Heart of the Bomb: The Dangerous Allure of Weapons Work. *Rosenthal, Debra,* Addison-Wesley, Redding, Mass., 1990, 244 pp., US $18.95.



Is there any town in the world like Los Alamos, N.M.? Is there any job like designing nuclear weapons? Has anything ever posed a problem as menacing as nuclear weapons?

These three questions are all raised in this book. The first is touched on lightly; the second is considered at length; and the third is generally dropped whenever it is broached. This is appropriate, since such a question is probably best addressed by the modern equivalent of Greek tragedy, rather than in a work of nonfiction for the general reader.

The book is on the whole anecdotal, rather than analytical. As such, it comes off more as a successful entertainment rather than an in-depth study. It is based principally on interviews (starting, ironically, in 1984) with 85 current and former employees of two of the principal U.S. nuclear weapons design facilities, Los Alamos National Laboratory, near Santa Fe, N.M., and Sandia National Laboratory, in Albuquerque, N.M.

Partly so that those interviewed might be more open and honest in expressing their feelings about their work, their identities are not given. One of the remaining giants of the original group of bomb designers, Edward Teller, is not among them; one of his conditions for a meeting—that he be told the names of all those interviewed—could not be met.

A background to their work and their thoughts is nicely sketched. Technical aspects of nuclear weapons are described in basic terms, and impressions are given of the general character of the two laboratories, the town of Los Alamos, and the state of New Mexico.

Rosenthal, who was on the faculty of the University of New Mexico in Albuquerque when the book was written, describes Los Alamos accurately and perceptively. But I cannot vouch for her picture of Sandia, which is located on a military base, since I have never been there. One hopes that its ambiance is not as grim as the impression of one of the young scientists who works there in what is described as a squared-off version of a Quonset hut: "It's just crazy to go to work in a place with barbed wire, guards, electrified fences, machine-gun nests. . . not a blade of grass, not a living cell, anywhere in the place."

Los Alamos, by contrast, has a fairly pleasant and relaxed atmosphere that is partly due to its setting at 2250 meters above sea level, on mesas cut by deep canyons, with the evergreen- and aspen-covered Jemez Mountains on one side and the snow-capped Sangre de Christo Mountains on the other. This provides a distraction from the architecture of most of its buildings, scattered over a wide area, which is described as "mostly 1960s prison style, with no particular coherence or grace." A thumbnail description of the laboratory as a "college campus without students" reminded me of my own first impression of Los Alamos—a suburb without a city.

The town's residents are mostly affluent, white, well educated, and proud of their low crime rate and numerous churches. Everything is clean and well ordered; parking lots, for example, are all carefully marked with the routes one is expected to take through them, even though they are usually fairly empty.

The town's dark side is manifested by high rates of alcoholism, brought on by boredom, and by teen-age drug use, brought on by affluence and boredom. The town's sometimes perceived racist character, which cannot really be separated from the lab, is briefly mentioned in a discussion of the attitudes of the scientists toward the guards, who are mostly Hispanics. (Curiously, Rosenthal does not allude to the claimed sexist nature of the laboratory, which has been the subject of lawsuits over the last 10–20 years.) Even though the inhabitants travel frequently, the town seems insular and somehow spiritually removed from the rest of the world.

One of Los Alamos's peculiarities is that while it has contributed more than any other place to a fundamental and irreversible change in the relations among humans and weapons and war, there are few visible indications of this—no signs, no monuments, and no logos, for example. There is a museum run by the laboratory that contains exhibits drawn from its weapons work, but it is so well hidden that only a determined tourist is likely to find it. Such covertness is perhaps a manifestation of the weapons designers' ambivalent feelings about their work, as expressed in interviews.

The reasons they give for doing weapons work range from the simple to the grandiose. At one end, they note that the pay is good, that someone has to do this job as a service to the nation, and that it is a great technical challenge (the "thrill of the chase" rationale). At the other end, they say that it is a deep expression of patriotism, a moral necessity as a deterrent to war, and an opportunity to be near something truly awesome and powerful (the "closest you get to playing God" rationale). Always hovering, however, is the question voiced by one of them: "What *if* one of these things actually should be used?"

An older scientist, who seems to contemplate these issues in greater depth than most, criticizes the younger ones for not concerning themselves enough with the moral and political significance of their work. However, one cannot help thinking, judging from the interviews, that they do not really want to do this, because the questions raised would be too disturbing.

The tensions that such thoughts generate, together with the necessity for secrecy, seem to lead to feelings of nervousness or restlessness that are reflected in certain aspects of the laboratory's management. The organization charts of both laboratories are changed so often as to be out of date almost before they are printed and distributed, interviewees report. The reasons given for this state of affairs are somewhat difficult to understand.

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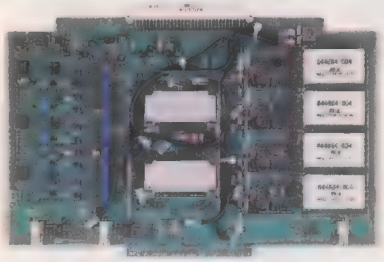
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BOOKS

(Continued from p. 11)

War has apparently faded into history, the nuclear threat is no less real. As the crisis in the Persian Gulf amply illustrates, the Third World is only beginning to react to the changing world order.

—George R. Burleson

George R. Burleson is professor of physics at New Mexico State University in Las Cruces. Throughout nearly three decades of research in nuclear and particle physics at Los Alamos and other Department of Energy laboratories, he has never had occasion to [illegible] classified information.

Spectacular Computer Crimes. *BloomBecker, Buck,* Business One Irwin (formerly Dow Jones-Irwin), Homewood, Ill., 1990, 242 pp., $22.95.



If this book had been better written, and, as a consequence, more credible, it might be mildly dangerous. With its jacket blurbs attributed to modestly prominent people in data processing, some of its readers might conclude—erroneously—that the book describes crimes that are archetypical of important computer security problems. They [illegible] not.

In the author's defense, it should be noted that it is difficult to gather information about economic crimes—particularly if it is known that plans exist to publish what is learned. Only about 10 percent of such cases ever make it to the judicial process, where they may be publicized—to the embarrassment of the offended organization. Stockholders, depositors, customers, and voters might see in such reports the results of gross mismanagement, and quite often, they would be right. Rare is the organization that will voluntarily display its managerial shortcomings by publicizing their consequences.

The crimes that become spectacular by virtue of their public disclosure are not typical computer-related crimes. In almost all such cases, some characteristic pushes them into the 10 percent that go public. Thus an analysis of this unusual group will not provide meaningful guidance in detecting and preventing the more typical crimes—the undisclosed ones that make up the other 90 percent.

The assertion that "one of the biggest problems facing computer security is the lack of agreement in the field [illegible] to the definition of computer crime" is nonsense. A far more important challenge is showing that prosecution is an effective deterrent to such misconduct. Only if that is possible does prosecution become [illegible] major security measure, one deserving of greater emphasis. Also of far greater importance is the implementation of cost-effective security measures to obviate the unnecessary and far too pervasive temptations that result in computer crime.

The book's many simple mistakes, such as a commission accounting job that is said to run on a mainframe computer from 1:00 a.m. until 3:30 p.m., [illegible] irritating. So is the assertion that the operator of a mainframe on a company's third shift knows all the people using the computer on all other shifts. There may be cases where this is true, but it is by no means a given in most companies.

Readers who have not followed the newspaper reports of the various computer misdeeds may find these accounts interesting. But BloomBecker owes himself and his readers [illegible] better job than is exhibited by this poorly written, poorly edited book. He is quite capable of it.

—Robert H. Courtney Jr.

Robert H. Courtney Jr. is president of Robert Courtney Inc., a Port Ewen, N.Y., consulting firm he started in 1981 to work with the private sector. Courtney worked for several years in product development at IBM Corp. before leading the company's computer security activities for 14 years.

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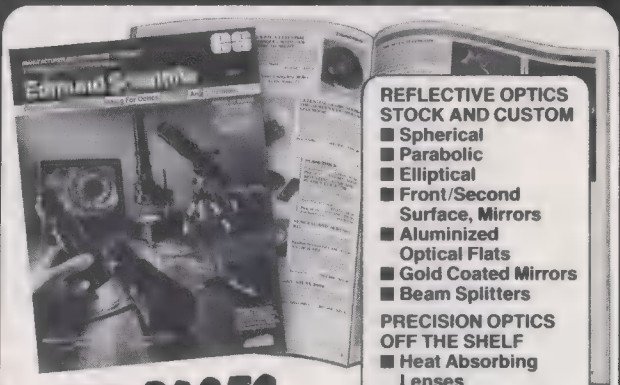
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pounds. *Ignatowicz, Stanislaw, and Kobendza, Andrezej,* Prentice-Hall, Englewood Cliffs, N.J., 1990, 420 pp., $131.95.

Running Windows for Version 3.0. *Stinson, Craig, and Andrews, Nancy,* Microsoft Press, Redmond, Wash., 1990, 544 pp., $24.95.

Information Transmission, Modulation, and Noise-4th Edition. *Schwartz, Mischa,* McGraw-Hill, New York, 1990, 742 pp., $55.95.

Graphics Programming with Microsoft C and Microsoft QuickC. *Jamsa, Kris,* Microsoft Press, Redmond, Wash., 1990, 624 pp., $24.95.

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Modern Digital Design. *Sandige, Richard S.,* McGraw-Hill, New York, 1990, 743 pp., $54.95.

Trends in Theoretical Physics (Volume 1). Eds. *Ellis, Paul J., and Tang, Y.C.,* Addison-Wesley, Menlo Park, Calif., 1990, 432 pp., $49.50.

Commercial Observation Satellites and International Security. Eds. *Krepon, Michael, et al.,* St. Martin's Press, New York, 1990, 230 pp., $45.

VLSI Design Techniques for Analog and Digital Circuits. *Geiger, Randall L., Allen, Phillip E., and Strader, Noel R.,* McGraw-Hill, New York, 1990, 969 pp., $54.95.

Computational Physics (Fortran Version). *Koonin, Steven E., and Meredith, Dawn C.,* Addison-Wesley, Menlo Park, Calif., 1990, 656 pp., $46.25.

Lighting Design Handbook. *Watson, Lee,* McGraw-Hill, New York, 1990, 458 pp., $69.50.

Languages and Compilers for Parallel Computing. Eds. *Gelernter, David, et al.,* MIT Press, Cambridge, Mass., 1990, 553 pp., $40.

Inside X.25: A Manager's Guide. *Schlar, Sherman K.,* McGraw-Hill, New York, 1990, 300 pp., $39.95.

The World & I (A Chronicle of Our Changing Era). Ed. *Kaplan, Morton A.,* The Washington Times Corp., Washington, D.C., 1990, 703 pp., $10.

Logic Programming. Eds. *Warren, David H. D., and Szeredi, Peter,* MIT Press, Cambridge, Mass., 1990, 788 pp., $55.

Manprint: An Approach to Systems Integration. Ed. *Booher, Harold R.,* Van Nostrand Reinhold, New York, 1990, 612 pp., $42.95.

AI and Expert Systems (A Comprehensive Guide-C Language)-2nd Edition. *Levine, Robert I., Drang, Diane E., and Edelson, Barry,* McGraw-Hill, New York, 289 pp., $24.95.

Design & Application of Security/ Fire-Alarm Systems (Revised Edition). *Traister, John E.,* McGraw-Hill, New York, 1990, 196 pp., $28.50.

The Essential Guide to VMS Utilities and Commands (VMS Version 5). *Sharick, Paula,* Van Nostrand Reinhold, New York, 1990, 291 pp., $24.95.

Microsoft C Run-Time Library Reference. Microsoft Press, Redmond, Wash., 1990, 844 pp., $22.95.

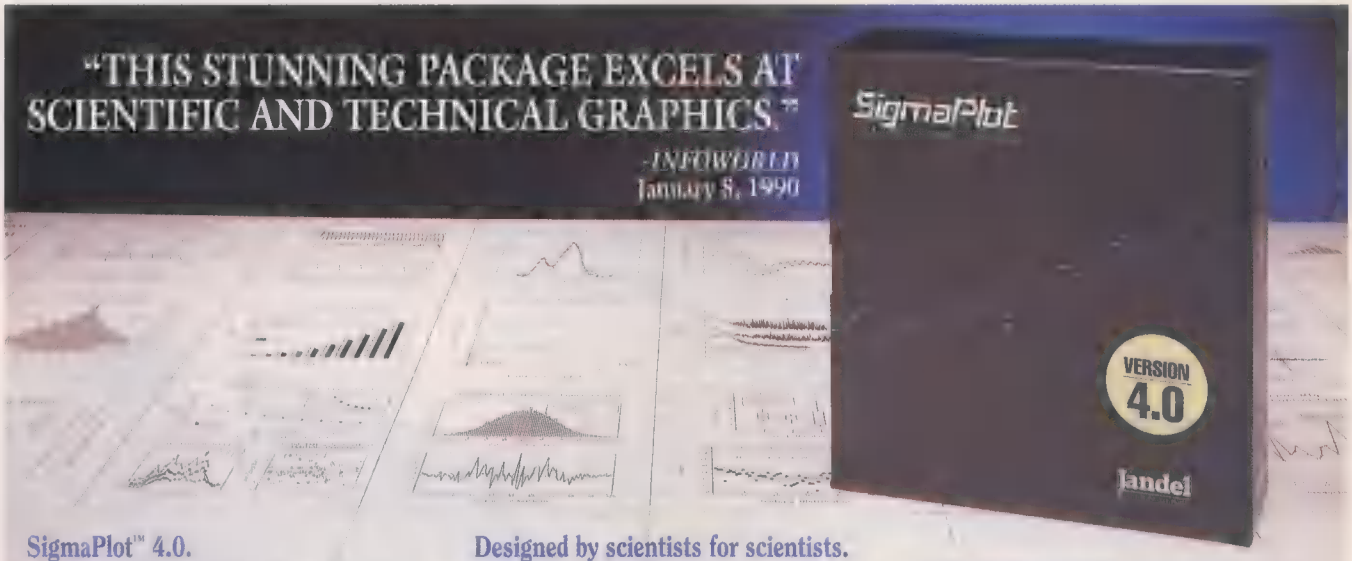
i486 Microprocessor (Programmer's Reference Manual). Intel Corp., Osborne/ McGraw-Hill, New York, 1989, $24.95.

Money Manager. *Nelson, Stephen L.,* Microsoft Press, Redmond, Wash., 1989, 265 pp., $34.95.

386 SX Microprocessor (Programmer's Reference Manual). Intel Corp., Osborne/ McGraw-Hill, New York, 1990, $24.95.

Running Microsoft Works (Covers Version 2). Ed. *Rubin, Charles, et al.,* Microsoft Press, Redmond, Wash., 387 pp., 1990, $19.95.

Rapid Reliability Assessment of VLSICs. *Dorey, A.P., et al.,* Plenum Press, New York, 1990, 202 pp., $59.50.



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Circle No. 12

Overlapping platforms and the IEEE voter

After voting for the IEEE President, I realized how little information I had on which to base my vote. I would like to propose a change in the way candidate statements are prepared and presented. I think it would lead to more intelligent voting and increase the percentage of members voting.

All candidates for an office should, in common, prepare a statement that as accurately as possible reflects the issues they feel they are likely to face during their term of office, if elected. For each issue, two or three alternative courses of action should be listed, along with reasons for and against them—all generally agreed to by the candidates. Then, referring to this mutually agreed-upon information, each candidate should state what distinguishes his or her position from that of the others, explaining why that position is preferable.

Extending that idea, I would like to see candidates, particularly those for President, again in common, list the dozen or so most important decisions made by the Board in the past year, along with alternative courses of action that were or should have been considered. Then each candidate should state whether he or she feels the best alternative was followed.

The IEEE and its members benefit greatly from the volunteer work done by its officers, who do not seek their positions for material gain. Any prestige they may get is some compensation for the amount of effort they devote to their work. Thus, I can foresee the reluctance on the part of some candidates to engage in my suggested process for fear that it might be viewed as ungrateful criticism of previous or potential officers. There would be a basis for such a fear, but it appears so small to me in comparison to truly presenting to the membership the alternatives before them and the support for each, that I feel it should not carry great weight.

Gerald D. Chandler
Red Bank, N.J.

From hobby to job

The absence of "tinkerers" among today's U.S. engineering students mentioned in Leon Zelby's letter [September, p. 11] is equally familiar in the United Kingdom.

As one who has tinkered with both automobiles and electronics throughout my teenage and adult life, I found it to be of great practical value when, as a result of job redundancy, I had to start my own business in my late 50s. I am really enjoying developing a line of marine search and rescue radar transponders after a career spent mainly in board-level engineering management.

Richard M. Trim
Leatherhead, Surrey, England

HDTV: a dissenting opinion

I do not believe it is desirable to have the transmitted signals of high-definition television (HDTV) compatible with current television technology. If HDTV is to be a significant improvement in TV technology, we need to change the way the signals are encoded. The current TV signal has already been modified to incorporate color, and this has resulted in poor color quality.

Having the color signal compatible with the current black-and-white TV sets probably made sense when color was introduced. I doubt that the costs to convert to color would have been worth the improvements if an incompatible signal had been used for color TV. It would have limited the acceptance of color, and delayed by many years the introduction of color TV sets into the average household.

The situation today is very different. When color TV was introduced, television had been around for only a few years. Almost 50 years have passed since the original TV standards were developed, and it is time to start fresh. Today the technology exists to develop economic converters from an HDTV into a National Television System Committee (NTSC) signal. If HDTV is limited to compatibility with current TVs and bandwidths, the resulting improvement in quality will be minimal.

I do not think it will be politically possible to extend the current bandwidth of TV signals using the currently allocated spectrum. If two bands are required for each channel, some TV stations are going to lose out. Encoding techniques can be used to reduce the bandwidth, but even with these techniques, which would make the signal incompatible with current televisions anyway, it is going to be very difficult to compact an 1100-line signal into one NTSC band.

The Federal Communications Commission needs to allocate new spectrum space to HDTV transmissions, which will probably mean direct satellite transmission. Since direct broadcast will use different frequencies, current TV sets will not be able to receive the signal.

The right approach is to develop converters of an HDTV signal to a signal compatible with that in current televisions. This should not be difficult. Already televisions that convert the interlaced signal into a noninterlaced signal to improve quality are on the market, and much talk has focused on using signal processing to eliminate ghosts.

Providing an HDTV-to-NTSC converter is not much harder. The only significant difference between converting NTSC interlaced to noninterlaced and an HDTV and NTSC converter is the speed required of the electronics and a minimal amount of additional processing. Memory requirements would not be significantly increased because the conversion would be to the smaller display size. If the signal is directly broadcast from a satellite, people who have poor reception and no cable access would have a very good reason to purchase converters. It would also provide competition for cable TV.

Instead of judging the proposals on compatibility with current NTSC televisions, we need to judge them on image/sound quality, the cost of a receiver and the NTSC converter, and the commitments in introducing programming and consumer hardware. I would urge serious consideration of using the Japanese standards so that the U.S. consumer is not unnecessarily burdened with the cost of developing the technology.

The U.S. government should provide the resources necessary (spectrum space, satellite technology, organizational support, and the like). Initially each station should cover a large portion of the continental United States and be allowed to use programming also available on the regular channels.

It is also a good idea to work on improving the NTSC standard since this standard will be around for a long time to come. A high-quality HDTV standard will probably do a lot to encourage improvement in the NTSC standard.

Clifford Nelson
Washington, D.C.

Our 0.2366 liter runneth over

I believe the magazine should go all out for metrication—lock, stock, and 159 liters. If any readers object, "Not in my back 0.914 meter!," urge that they go the extra 1.609 km; otherwise the impact of worldwide metrication will hit them like 907.2 kg of bricks.

Metrication will help give U.S. industry the 745.7 W it needs to compete in the world of the future. Anything short of this is penny-wise and 0.454 kg-foolish.

The English system? I wouldn't touch it with a 3.05-m pole!

Thomas W. Parsons
Brooklyn, N.Y.

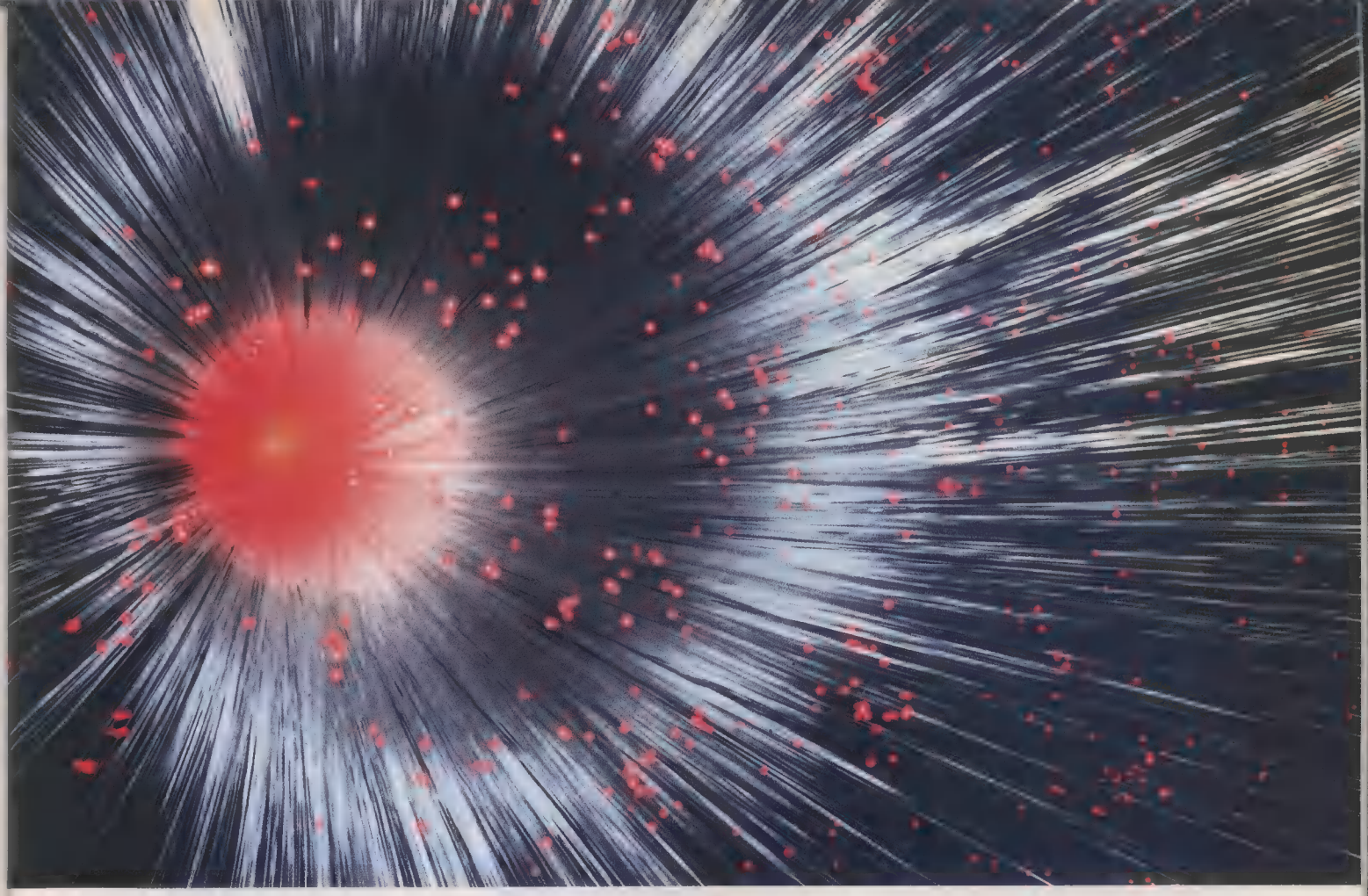
Corrections

On p. 18 of the September issue, the equivalent of an inch should have been 2.54 centimeters.

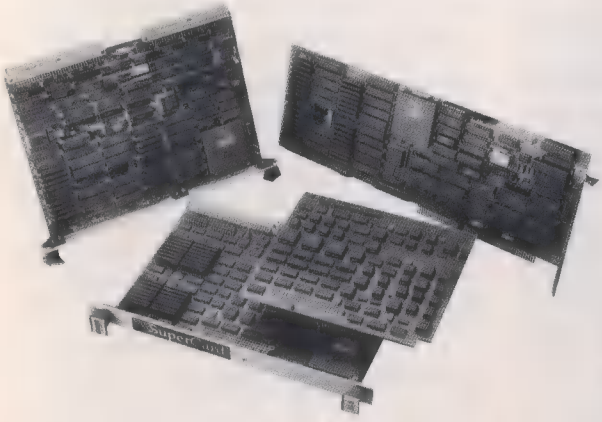
On p. 93 of the November issue, Fred Taylor should have been described as president of The Athena Group Inc.

On p. 69 and p. 73 of the December issue, the illustrations should have been credited to Barry Ross. —*Ed.*

Readers are invited to comment in this department on material previously published in *IEEE Spectrum*; on the policies and operations of the IEEE; and on technical, economic, or social matters of interest to the electrical and electronics engineering profession. Short, concise letters are preferred. The Editor reserves the right to limit debate on controversial issues.



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Circle No. 3

Antique reproduction by laser techniques

Manufacturers at the high end of the furniture market in recent years have turned more and more to lasers and computer numerical control (CNC) to produce or reproduce intricate designs.



The most complicated designs are found in fretwork, a linear pattern of decorative motifs, and in marquetry, decoration formed by inserting pieces of material like wood or shell into a wood veneer attached to a piece of furniture.

At the Baker Furniture Co.'s factory in Mocksville, N.C., a 700-watt helium laser is operated in three shifts to cut furniture fretwork and marquetry. Most of the items made there are antique reproductions.

The laser can only cut wood up to ¾ inch (2 centimeters) thick. "Beyond that, the wood tends to catch on fire before the laser cuts through it," said Michael Hinshaw, the plant manager.

Also, the laser may leave a dark burn residue on light woods, according to Donald Milton, director of materials at Baker headquarters in Grand Rapids, Mich.

The factory has reproduced antique furniture from former plantation homes for the Charleston Historical Society in Charleston, S.C. To draw blueprints to actual scale, a team of designers visits the Society to take notes, photographs, and measurements of the antiques, sometimes returning with one on loan.

With the blueprint, a programmer uses a mouse with cross hairs to line up a multitude of points that define the design, plotting them into a PC program. Most plotting takes a few hours, but intricate fretwork may require up to eight. Using another program, the programmer then smooths the points into a curve, reproducing the blueprint on-screen.

The PC is linked to a cutting apparatus consisting of a laser and a surface that moves the piece of wood into position. On average, the laser system carves fretwork in half the time it would take with a fretsaw. For intricate fretwork, the savings is about seven-eighths of the time.

Marquetry exacts even more exquisite cutting. Strips or pieces of one kind of wood or other material are cut by laser and then placed by hand into a design, which is glued to the surface of another kind of wood to form, say, a rose pattern on a coffee table top. The top veneer is reinforced by a second layer of veneer with opposite grain, a third layer of lumber panel, and two more layers of veneer. The five layers are then pressed together at 250 pounds per square inch (1700 kilopascals) at 250 °F for 4–5 minutes.

To scout out ideas for their antique reproductions, Baker Furniture designers have traveled throughout the world during the past century. Some antiques they purchased to imitate are housed in the Baker Furniture Museum in Holland, Mich.

In the past four years, the company has spent US $10 million to replace the machinery in its six factories with CNC equipment. This has enabled Hinshaw's factory to take on work formerly done by subcontractors.

Out of thin air

Scientists who study aeroponics, the growth of plant tissue or seeds in a nutrient-rich mist without soil or water, can now get help from a device called the Mistifier system.

Developed by Bio Rational Technologies in Stow, Mass., but marketed by Manostat Corp. in New York City, the system employs a horizontal growth chamber about the size of a household ultrasonic humidifier. A tube inside the chamber evenly disperses nutrient mist from an ultrasonic mist generator over a perforated stainless steel tray.

An electronic controller regulates the system's various settings. These include a control that determines fluid level in the mist generator by regulating a peristaltic pump (which pumps fluid by waves of mechanical contractions along the tubing), a flowmeter that determines the rate of gas flow through the system, and a control for intermittent mist generation.

Finding a wood substitute

A Cray supercomputer at the Pittsburgh Supercomputing Center at Carnegie Mellon University in Pittsburgh was tapped to determine whether a man-made material could replace the wood of scarce Norway spruce in violin top plates. The wood is recognized as the best material for violin top plates because of its acoustical characteristics, but in recent years, Norway spruce forests have been decimated by air pollution and natural stresses.

Because Norway spruce is 20 times stronger across the grain than with the grain, its compliance depends on the direction in which the deforming force is applied. And because the top plate is arched and not flat, nine elastic-compliance elements are required to describe it completely.

Traditionally, violin makers have tested wood for the top plate by judging three elastic-compliance elements—bending it upward and downward and then twisting it—to determine the ratio of elastic deformation to applied force.

Robert Schumacher, a physics professor at Carnegie Mellon who plays the violin, decided to test the importance of the six other elastic-compliance elements that violin makers have ignored. He modeled a flat top plate and several arched variations using a finite-element package called Abaqus to compute their normal-mode frequencies (which have a stationary vibration pattern).

Schumacher found that three elastic constants do indeed adequately describe Norway spruce. Next he calculated normal-mode frequencies of carbon fiber-epoxy, which, like other man-made composites, has fewer elastic-compliance elements than wood. The results were similar to those for Norway spruce.

Monitoring oxygen in the brain

Doctors at the University of Pennsylvania School of Medicine in Philadelphia are testing a blood-oxygen–monitoring device that may reduce the risk of brain damage in patients undergoing surgery.

The Near Infrared Reflectance Spectroscopy (NIRS), as it is called, was developed by Britton Chance, a professor emeritus of biochemistry and biophysics. It uses photosensitized detectors to monitor changes in blood-oxygen levels in the brain, possibly more quickly than do present methods in which the lungs' intake of oxygen and the oxygen saturation of the hemoglobin in arterial blood are measured. Monitoring is critical for patients whose blood flow must be interrupted in, say, open-heart surgery; if blood oxygen dips below a threshold, patients can suffer brain damage.

To monitor patients, a doctor attaches a headband containing a pen light bulb and a light sensor to the patient's head. The light bulb passes light through the skin and skull into the brain, and the sensor then reads the reflected light. Changes in the amount of light absorbed indicate the amount of oxygen present.

Coordinator: Katherine T. Chen
Consultant: Allan E. Alcorn, Apple Computer Inc.

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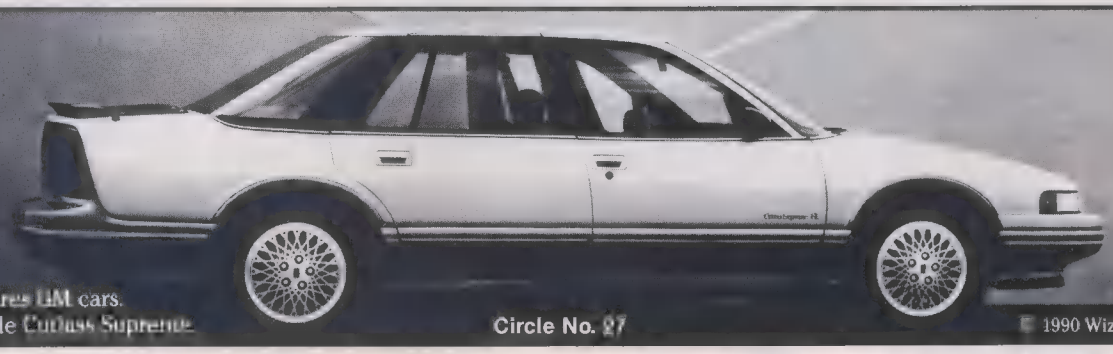
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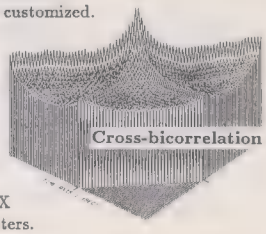
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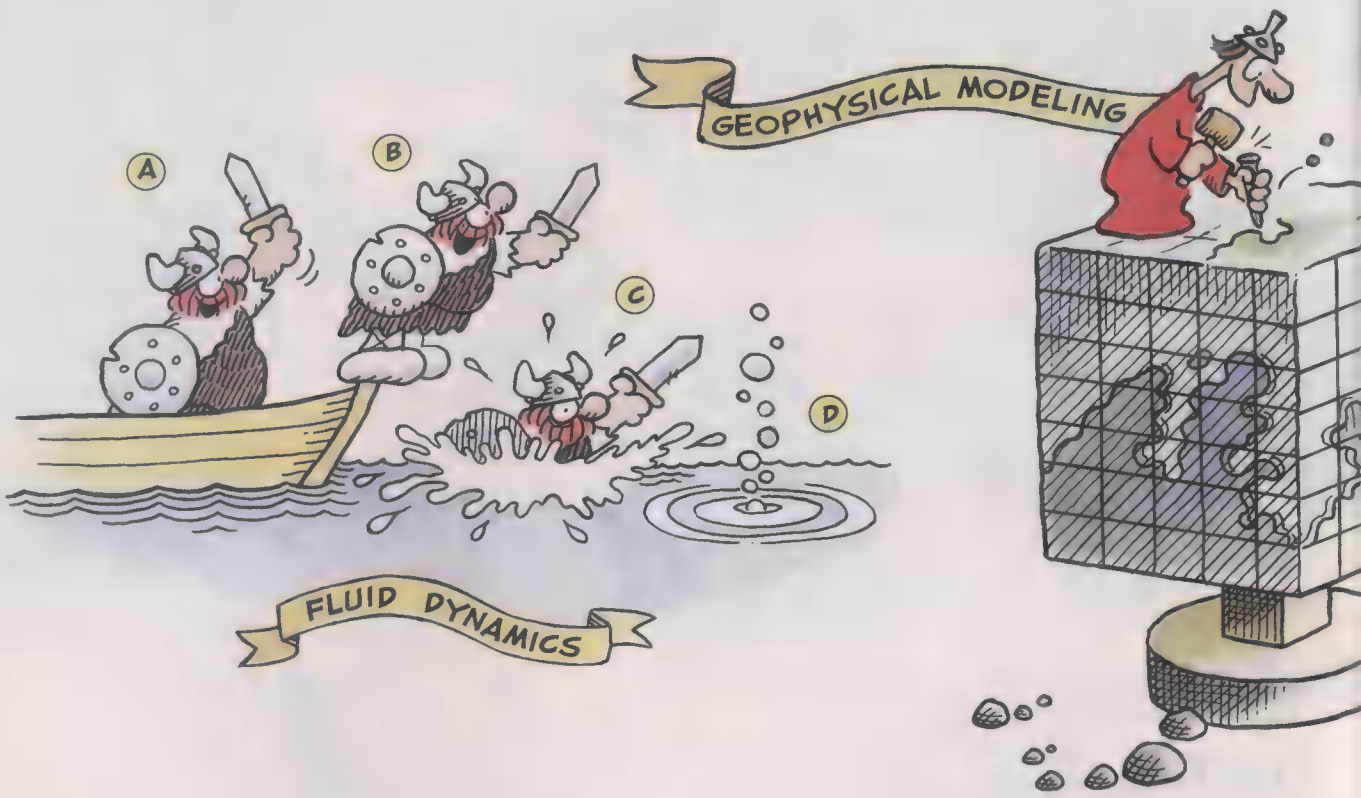
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(Continued from p. 8)

International Conference Control '91 (UKRI Section); March 25-28; Edinburgh Conference Centre, Heriot-Watt University, Edinburgh, Scotland; Louise Bousfield, IEE Conference Services, Institution of Electrical Engineers, Savoy Place, London WC2R OBL, England; (44+1) 240 1871; fax, (44+1) 240 7735.

APRIL

Second International Symposium on Integrated Network Management (IFIP et al.); April 1-5; Crystal Gateway Marriott, Washington, D.C.; Action Motivation, Box 191885, San Francisco, Calif. 94119; 415-392-3751.

Southeastcon '91 (Region 3 et al.); April 7-10; Fort McGruder Inn, Williamsburg, Va.; Griffith G. McRee, 525 Virginia Deare Dr., Virginia Beach, Va. 23451; 804-683-4897 (O) or 804-428-0083 (H).

Infocom '91 (COMP, COMM); April 7-11; Sheraton Bar Harbour, Bar Harbour, Fla.; Ken Joseph, Bell Canada, 160 Elgin St., Ottawa, Ont. K1G 3J4, Canada; 613-781-7214; fax, 613-234-1442.

First International Workshop on Interoperability in Multidatabase Systems (COMM); April 8-9; Kyoto University, Kyoto, Japan; IEEE Computer Society Conference Services, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013; fax, 202-728-0884.

Third International Conference on Indium Phosphide and Related Materials (ED); April 8-10; Park Hotel, Cardiff, Wales, UK; Robert Wangemann, IEEE Service Center, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855-1331; 201-562-3895.

International Reliability Physics Symposium (ED, R); April 8-11; Caesars Palace, Las Vegas, Nev.; Alfred L. Tamburrino, RADC/ RBRP, Griffiss AFB, N.Y. 13441-5700; 315-330-2813.

Ninth Annual IEEE VLSI Test Symposium (COMP et al.); April 16-18; Bally's Park Place Casino Hotel, Atlantic City, N.J.; William Zacker, 40 Gill Lane, Woodbridge, N.J. 07095; 201-636-8616.

International Symposium on Power Semiconductor Devices (ED); April 22-24; Baltimore, Md; M. Ayman Shibib, AT&T Bell Laboratories, 2525 N. 12th St., Reading, Pa. 19612; 215-939-6576.

10th International Symposium on Computer Hardware Description Languages and their Applications (IFIP et al.); April 22-24, Marseille, France; Ronald Waxman, Department of Electrical Engineering, Thornton Hall, University of Virginia, Charlottesville, Va. 22903-2442; 804-924-6086.

International Symposium on Subscriber Loops and Services-ISSLS '91 (COMM et al.); April 22-25; Raicongrescentrum Europaplein, Amsterdam, The Netherlands; Paul 't Hoen, PTT Netherlands, Box 39, 2260 AA Leidsehenam, The Netherlands; (31+70) 43 22 33; fax, (31+70) 43 21 40.

International Workshop: Quality of Telecommunications Services and Products (IEEE QAMC); April 23-25; Val David, Canada; V. Seshadri, Room 3J536, AT&T, Crawfords Corner Road, Holmdel, N.J. 07733.

MAY

IEEE/IAS Industrial and Commercial Power Systems Conference-I&CPS '91 (IA); May 6-9; Hilton Inn, Memphis, Tenn.; Allan H. Long, Memphis Light, Gas & Water Division, Box 430, Memphis, Tenn. 38101-0430; 901-528-4859.

Compeuro '91-IEEE Fifth International Conference on Advanced Computer Technologies, Systems, and Applications (COMP et al.); May 7-10; Bologna, Italy; V. A. Monaco, Dip. Elettronica, Informatica e Systemistica, University of Bologna, Viale Risorgimento 2, 1-40136, Bologna, Italy.

Power Industry Computer Applications Conference-PICA '91 (PE); May 7-10; Hyatt Regency/ Sheraton, Baltimore, Md.; William Keagle Jr., Baltimore Gas & Electric Co., Electric Test Facility-RBC, Box 1475, Baltimore, Md. 21203; 301-281-3788.

IEEE Pacific Rim Conference on Communications Computers and Signal Processing (Victoria Section), May 9-10; Dr. Pan Agathoklis, Department of Electrical and Computer Engineering, University of Victoria, Box 3055, Victoria, B.C., Canada V8W 3P6; 604-721-8618.

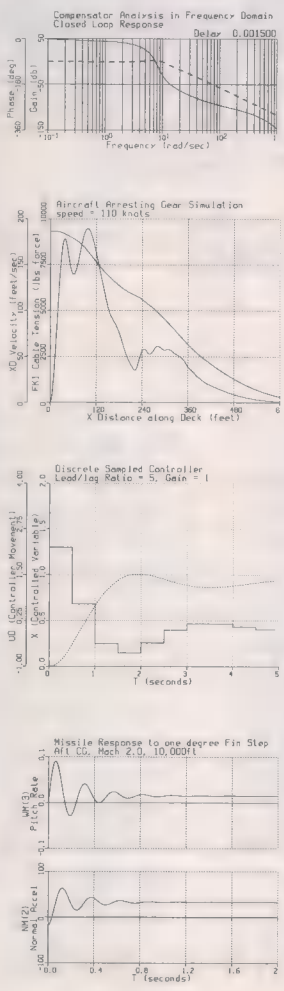
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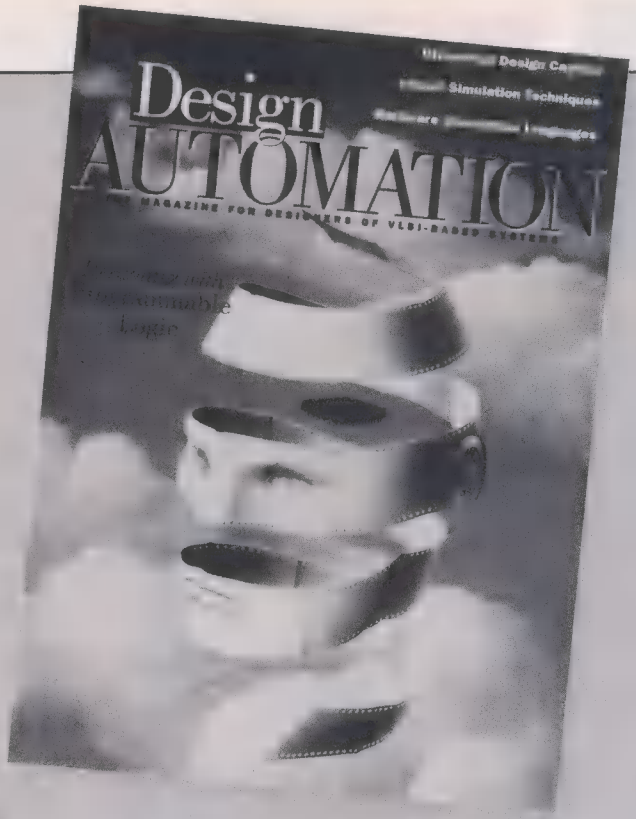
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CALENDAR

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Custom Integrated Circuits Conference (ED); May 12-15; Town and Country Hotel, San Diego, Calif.; Laura Morihara, Convention Coordinating, 298 Ohina Place, Kihei, Maui, Hawaii 96753; or Roberta Kaspar, 1597 Ridge Rd. W., Suite 101C, Rochester, N.Y. 14615; 716-865-7164; fax, 716-865-2639.

Ideas in Science and Electronics Symposium and Exposition (IEEE Albuquerque, et al.); May 14-16; Albuquerque Convention Center, Albuquerque, N.M.; Dave Smoker Communications, 218 Manzano N.E., Albuquerque, N.M. 87108; 505-266-7292; or Charles E. Christmann, c/o ISE Inc.; 505-262-1023.

Vehicular Technology Conference (VT et al.); May 19-22; Sheridan West Port Inns, Maryland Heights, Mo.; Jay Underdown, 58 Judy Dr., St. Charles, Mo. 63301; 314-946-9980 (O); 314-723-4200 (H).

National Aerospace and Electronics Conference–NAECON '91 (AES et al.); May 20-24; Dayton Convention Center, Dayton, Ohio; Sue Brown, ASD/ ENES, Wright-Patterson AFB, Ohio 45433-6503; 513-255-6281.

Annual IEEE/ASME Joint Railroad Conference (IEEE et al.); May 21-23; St. Louis, Mo.; Robert B. Fisher, Land Transportation Division, Southeastern Pennsylvania Transportation Authority, 5800 Bustleton Ave., Philadelphia, Pa. 19149; 215-580-4888.

International Symposium on VLSI Technology, Systems, and Applications (ED); May 22-24; Lai Lai Sheraton Hotel, Taipei, Taiwan; Alice Chiang, 617-981-4629.

Mediterranean Electrotechnical Conference (Region 8); May 22-24; Ljubljana, Yugoslavia; Baldomir Zajc, Fakuteta za Elektrotehniko, Trzaska 25, 61000 Ljubljana, Yugoslavia.

JUNE

Fourth International Conference on Industrial and Engineering Applications of Artificial Intelligence and Expert Systems (COMP et al.); June 2-5; Waiohai Hotel, Kauai, Hawaii; Moonis Ali, University of Tennessee Space Institute, MS15, B.H. Goethert Parkway, Tullahoma, Tenn. 37388; 615-455-0631, ext. 236; fax, 615-454-2354.

IEEE Pulp and Paper Industry Conference (IA); June 3-7; Hotel des Gouverneurs Lerand, Montreal; Michael Riverin, Relcon Inc., 2535 Cavendish Blvd., Montreal, Que., Canada; 514-487-6111.

Intensive Course on Electrical Contacts (IEEE/CHMT); June 3-7; Radisson Plaza Raleigh, Raleigh, N.C.; IEEE Holm Conference Registrar, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855-1331; 908-562-3863; fax, 908-562-1571.

International Microwave Symposium–MTT '91 (MTT); June 11-13; Hynes Convention Center, Boston; Peter Staecker, MA-COM, 52 South Ave., Burlington, M/S 704, Mass. 01803; 617-272-3000, ext. 1602.

(Continued on p. 18L)

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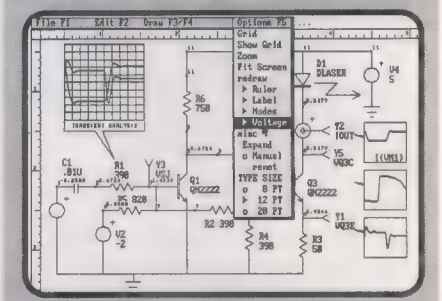
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CALENDAR

(Continued from p. 18J)

Device Research Conference (ED); June 16-19; University of Colorado, Boulder; Larry Coldren, University of California, Department of Electrical Engineering and Computer Engineering, Santa Barbara, Calif. 93106; 805-893-4486.

Eighth IEEE Pulsed Power Conference (ED); June 17-19; Sheraton Island Habor Hotel, San Diego, Calif.; Roger White, 619-576-7884.

University/ Government/ Industry Conference (ED); June 18-20; Melbourne Holiday Inn, Oceanside, Fla.; Thomas Sanders, Florida Institute of Technology, 150 W. University Blvd., Melbourne, Fla. 32901; 407-768-8000, ext. 8769/ 8763.

Joint Magnetism and Magnetic Materials-Intermag Conference (MAG); June 18-21; Pittsburgh Hilton, Pittsburgh; Diane Suiters, 5M3I Conference Coordinator, 655 15th St., N.W., Suite 300, Washington, D.C. 20005; 202-639-5088; fax, 202-347-6109.

International Conference on Communications (COMP); June 23-26; Denver Technical Center, Hyatt and Sheraton, Denver, Colo.; Russell Johnson, Western-Telecommunications Inc., 4643 S. Ulster St., Suite 400, Denver, Colo. 80237; 303-721-5650.

Antennas and Propagation Society International Symposium and URSI National Radio Science Meeting (AP); June 23-27; University of Western Ontario, London, Ont., Canada; A. R. Webster, Faculty of Engineering Science, University of Western Ontario, London, Ont. N6A 5B9, Canada; 519-679-6294.

International Symposium on Information Theory (IT); June 23-28; Budapest, Hungary; Anthony Ephremides, Department of Electrical Engineering, University of Maryland, College Park, Md. 20742; 301-405-3641.

Power Electronics Specialist Conference– PESC '91 (PEL); June 24-28; Massachusetts Institute of Technology (MIT), Cambridge; Martin Schlecht, MIT, Room 39-553, Cambridge, Mass. 02139; 617-253-3407.

Transducers '91: International Solid-State Sensors and Actuators Conference (ED); June 24-28; Hyatt Regency Hotel, San Francisco; Richard S. Muller, 497 Cory Hall, Berkeley Sensor & Actuators Center, Department of Electrical Engineering and Computer Science, Electronics Research Laboratory, University of California at Berkeley, Berkeley, Calif. 94720; 415-642-0614.

American Control Conference-ACC '91 (CS); June 26-28; Boston; Timothy Johnson, General Electric Co., Research and Development, KWD 217, Box 8, Schenectady, N.Y. 12345; 518-387-5096.

JULY

28th IEEE Nuclear and Space Radiation Effects Conference (IEEE Nuclear and Plasma Sciences Society); July 15-19; Town and Country Hotel, San Diego, Calif.; James R. Schwank, Sandia National Laboratories, Division 2144, Box 5800, Albuquerque, N.M. 87185; 505-846-8485.

AUGUST

International Symposium on Electromagnetic Compatibility-EMC '91 (EMC et al.); Aug. 13-15; Hyatt Cherry Hill, Cherry Hill, N.J.; Henry W. Ott, 45 Baker Rd., Livingston, N.J. 07039; 201-386-6660.

SEPTEMBER

Bipolar Circuits and Technology Meeting (ED); Sept. 9-10; Minneapolis Marriott Hotel, Minneapolis, Minn.; John Shier, 2401 E. 86th St., Bloomington, Minn. 55425; 612-851-5228.

Petroleum and Chemical Industry Technical Conference (IA); Sept. 9-11; Royal York, Toronto; Barry Wiseman, Reliance Electric Co., 5220 Creekbank Rd., Mississauga, Ont., Canada L3W 1X1; 416-625-8112.

Third International Conference on Microstructures in Biological Research (ED); Sept. 9-12; Martin Peckerar, 202-767-3150.

Seventh Multidimensional Signal Processing Workshop (SP); Sept. 23-25; Whiteface Inn, Lake Placid, N.Y.; John Woods, Computer and Systems Engineering, Rensselaer Polytechnic Institute, Troy, N.Y. 12181; 518-276-6079.

18th International Conference on Computers in Cardiology (COMP et al.); Sept. 23-26; Venice, Italy; Corso Stati Uniti 4, 35020 Padova, Italy; (39+49) 829 5702.

International Symposium on Gallium Arsenide and Related Compounds (ED); Sept. 23-26; Seattle, Wash.; L. Ralph Dawson, 505-846-3451.

Fourth Annual IEEE International Application Specific Integrated Circuits Conference and Exhibit (IEEE Rochester, C); Sept. 23-27; Rochester Riverside Convention Center, Rochester, New York; Kenneth W. Hsu, Department of Computer Engineering, Rochester Institute of Technology, Rochester, N.Y. 14623; 716-475-2655; fax, 716-475-6879.

OCTOBER

Fourth International Conference on Amorphous and Crystalline Silicon Carbide and Other IV-IV Materials (ED); Oct. 10-11; Santa Clara University, Santa Clara, Calif.; Cary Yang, 408-554-6814.

International Display Research Conference (ED); Oct. 15-17; Hyatt Islandia Hotel, San Diego, Calif.; Andras Lakatos, 716-422-9700.

37th IEEE Holm Conference on Electrical Contacts (CMHT); Oct. 6-9; Marriott Downtown, Chicago; Conference Registrar, IEEE, Inc.; 201-562-3863.

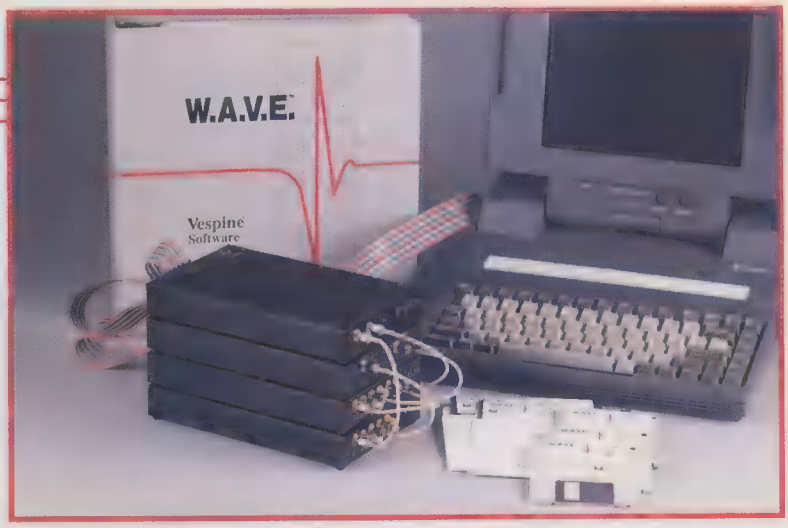
International Joint Power Generation Conference (IJPGC '91) (PE); Oct. 6-9; Town and Country, San Diego, Calif.; M. Scalice, 212-705-7053.

VNIS '92-1991 Vehicle Navigation and Information Systems Conference (VT); Oct. 20-23; Troy, Mich.; Mark K. Krage, 313-986-2976.

MILCON '91-IEEE Military Communications Conference (COM); Oct. 20-23; McLean Hilton, McLean, Va.; Faye Burke, 703-883-6733.

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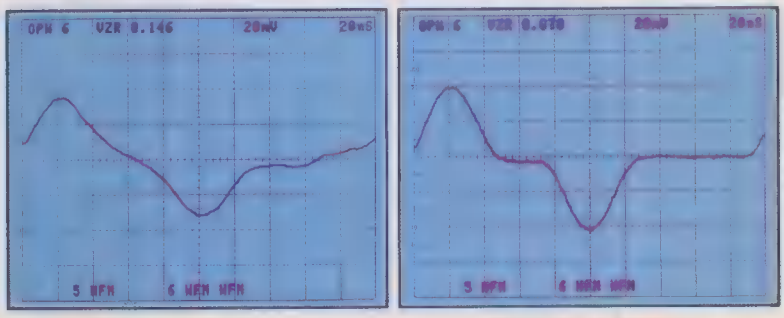


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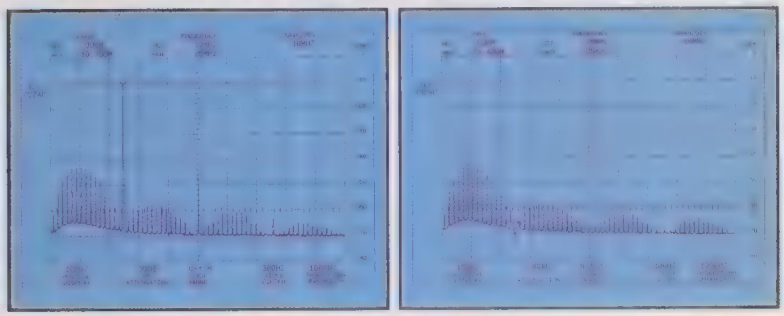
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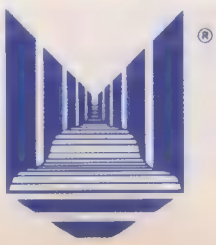
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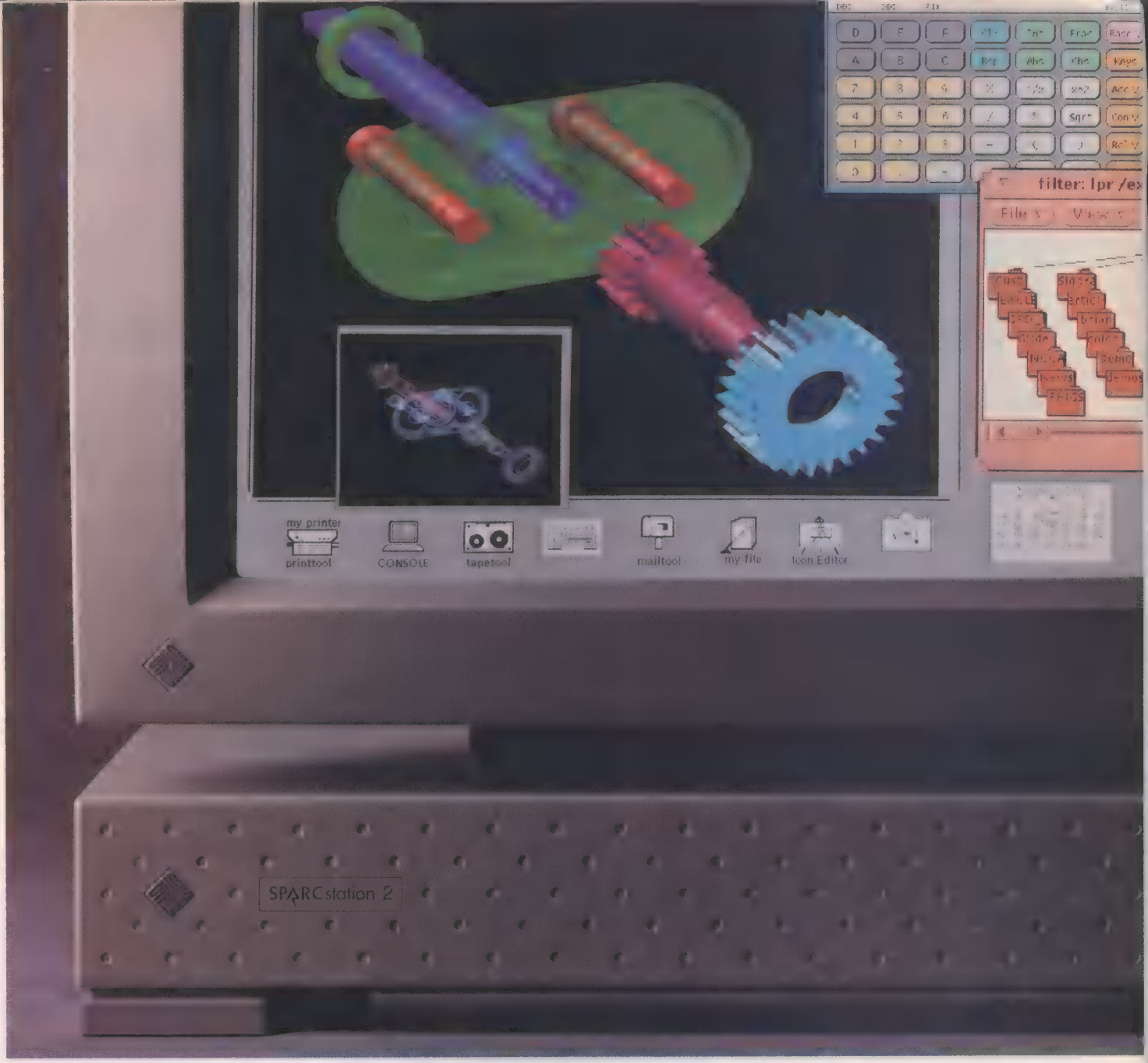
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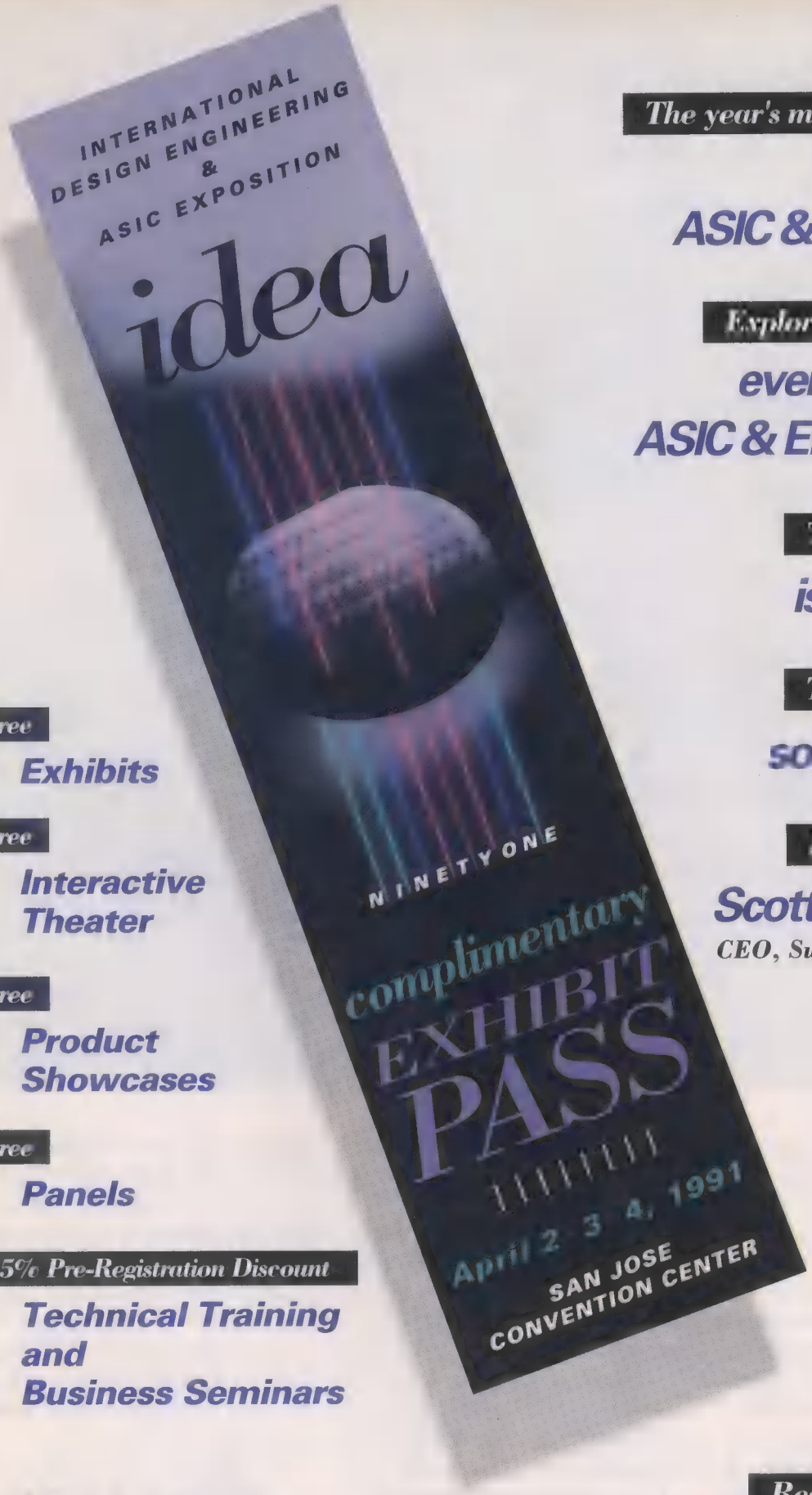
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EasyPlot. Spiral Software. Scientific Plotting & Data Analysis IBM PC or compatible; 350K bytes of memory. EGA, VGA, or Hercules graphics card required. US $349. ($269 for government and academic institutions.)

EasyPlot lived up to its name because I was plotting useful data within the first half hour. During the next several months I needed to read only small portions of the manual and still managed to produce hundreds of plots. The Version 1 manual is a mere 120 pages and provides quick access to needed information. It is also clearer and more concise than most software documentation, and very nearly complete. The technical support was prompt and excellent.

EasyPlot gets its inputs from data files. Multiple data files and/or multiple columns of data can be entered. This contrasts with some other plotting software consisting of Fortran or C callable subroutines that the user includes in a computer program. I much prefer the approach used by EasyPlot, since it does not require writing plotting programs or reprogramming to change plot format.

EasyPlot has six pulldown menus, a number that is easy to manage and can be grasped quickly. They can be operated using a mouse or from the keyboard. Another extremely useful and versatile feature is that text commands placed in an input file can operate EasyPlot. The file containing these plotting commands may be the same input file as the one that contains the numerical input data points to be plotted, or it may be a separate file. This feature allows a plot to be saved and then modified slightly by editing the input file. It also permits a series of plots to be automatically generated and printed from a batch file. If the program that generates the numerical data also writes some text, then each plot can be uniquely titled, annotated, plotted, and printed with no user intervention.

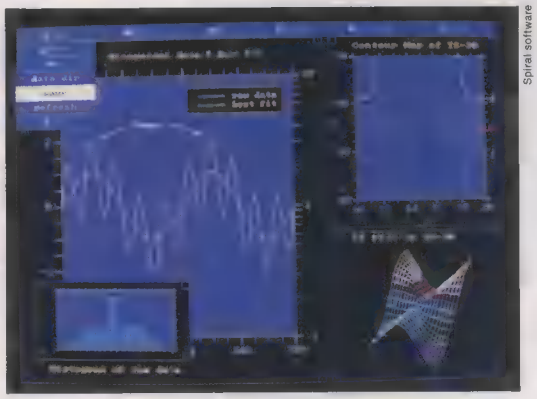
In addition to numeric input consisting of lists of data points, short equations can also be typed in and plotted: a timesaver in some instances. These equations can include references to typical trigonometric and logarithmic functions. Data may also be graphically analyzed (a fast Fourier transform, curve fitting, and so on are cases in point).

I have used EasyPlot mostly for two-dimensional rectangular and polar plots and three-dimensional contour plots. It also turns out 3-D mesh plots and multiple plots on one page, but I have made too little use of those two features to comment on them.

EasyPlot plots very quickly to the screen on my 386-compatible. The data files usually require about 0–5 seconds to read in and then the curves appear almost instantly on the screen. Hard copies are quickly printed on a PostScript-based QMS laserjet printer, but frustratingly slow on a Hewlett-Packard Laserjet II (several minutes per copy)—and the computer is tied up during that time. Laserjet II uses an earlier and less efficient graphics printing technique than the PostScript-based printers do.

Problems do exist with EasyPlot (some may be corrected in future versions—this review is based on Version 1 documentation and a beta version of the Version 2 software). For plotting 3-D (*xyz*) data the *x* and *y* increments between data points must be equal. Values associated with contour levels are not automatically placed on contour curves, but must be moved there by the user.

Getting a legend to appear is not always straightforward. Also, what you see on the screen is not always exactly what you get on a hard copy since the size of legend boxes is relatively larger on the copy than on the screen (which sometimes obscures portions of curves).



Spiral software

Error conditions such as running out of memory are poorly handled, sometimes hanging the machine or leaving it in bizarre (to me) graphics modes. The vertical axis is called the *y* axis, but one feature I felt to be anti-intuitive is that the dependent variable (which must be specified for legends) is not always *y*—if the *x* data was listed after the *y* data in the input file, it is *x*.

Despite these few minor difficulties, I like using EasyPlot and would recommend it to anyone looking for a plotting package for under $500. *Contact: Spiral Software, 6 Perry St., Suite 2, Brookline, Mass.; 617-739-1511. In Europe: Cherwell Scientific Publishing Ltd., 27 Park End St., Oxford OX11HU, UK; (44+0865) 794 884; fax, (44+0865) 794 664,* **or circle 55.**

—Paul G. Elliot

Paul G. Elliot (M) is a research engineer at ARCO Power Technologies Inc., Washington, D.C., where his responsibilities include computer modeling of RF phased-array antennas and impedance-matching circuits, electromagnetic propagation, and scattering problems. He has authored or coauthored 26 engineering reports and publications.

Coordinator: Gadi Kaplan

RECENT SOFTWARE

Many alternatives to Spiral Software's EasyPlot package exist—so many, that while some were listed in *IEEE Spectrum*'s Focus Report on "Displaying processed data" [November 1990, pp. 86–89], it is not surprising that the following were omitted. All run on IBM PCs or compatibles and will produce a variety of scientific plots.

GraphicC (US $395). Good-quality graphics, lots of features; can be programmed to do 3-D plots. Site license available. Consists of subroutines which then require C programming to create plotting programs; requires C compiler. *Scientific Endeavors Corp.*, 508 N. Kentucky St., Kingston, Tenn. 37763; 615-376-4146.

Microplots ($299, free demo disk). Will accept a wide variety of input data formats and very large input data files. Will plot multiple plots per page. Will not plot directly to a dot-matrix printer unless passing data through a word processor. *Scientific Concepts Inc.*, 2359 Windy Hill Rd., Suite 201-J, Marietta, Ga. 30067; 404-438-4181.

PLOT88: ($299 to $399, depending on compiler used with it). Consists of Fortran or C callable plotting routines; provides contour and 3-D mesh capabilities; many output devices are supported, as are several compilers. *Plotworks Inc.*, 16440 Eagles Crest Rd., Ramona, Calif. 92065-9674.

Graph-in-the-Box ($69). Widely available. Low cost, easy to use. Mainly for general business use; no 3-D or contour plotting capability; *x*-axis increments between data points must be uniform. *New England Software Inc.*, 3 Greenwich Office Park, Greenwich, Conn. 06831; 203-625-0062.

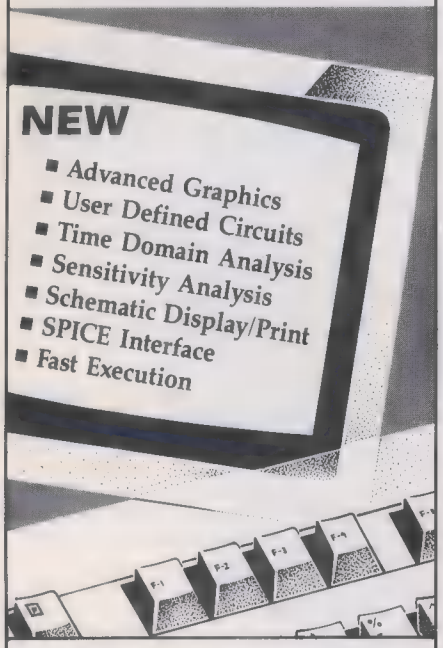
Plotz Graphics ($350). Also does data analysis; offers an unusual capability—a digitizer input which uses plotter as an *xy* digitizer; no mention of, or pictures of, 3-D or contour plots in ad. *Curtis Technical Software Corp.*, Box 178, Pennington, N.J. 08534; 609-737-8844.

Data Graph ($299). Ad shows a variety of two-dimensional but no 3-D plots. *Mihalisin Association*, 600 Honey Run Rd., Ambler, Pa. 19002; 215-646-3814.

Harvard Graphics ($299). Widely available. Easy to use and high-quality graphics; also makes very large text for viewgraphs. Line plots limited to 240 points per curve, all the curves must be in different columns and in one data file—cannot also input different curves from different data files; mainly for general business use. *Software Publishing Corp.*, 1901 Landings Dr., Box 7210, Mountain View, Calif. 94039; 415-962-8910.

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The neutron bomb

This, in effect, is what the neutron bomb is. . .a bomb by means of which it would be possible to kill people but to preserve all riches—here it is, the bestial ethics of the most aggressive representatives of imperialism.—Nikita Khrushchev, in a speech to the Rumanian Party Congress, 1961


U.S. Army

At the height of the Cold War in the late 1950s, a tremendous amount of research was under way to enhance and modernize the U.S. nuclear arsenal. The growing perception of Soviet superiority in conventional arms placed ■ high priority on the development of new nuclear weapons. The most likely scenario was a nuclear conflict starting in densely populated Europe, devastating most of it in the process.

Yet when the neutron bomb, a nuclear weapon that maximizes damage to people but minimizes damage to buildings and equipment, was nearing deployment in the 1970s, the ethical and political repercussions ignited a firestorm of debate that engulfed most of the Free World. In the end, however, this ultimate weapon has become a forgotten pawn in a game of global politics.

Since the early 1950s, there have been two main weapons in the U.S. nuclear arsenal: atomic and hydrogen bombs. The atomic bomb, of the type dropped on Nagasaki in 1945, uses ■ chemical explosion to compress a core of purified plutonium, resulting in an uncontrolled fission that releases tremendous heat and energy. The fission products and by-products formed by the radiation produce the lethal and long-lived fallout associated with nuclear weapons.

A hydrogen bomb, on the other hand, produces most of its energy by the fusion of heavy isotopes of hydrogen, such as deuterium and tritium. The energy needed to start the fusion reaction is obtained when chemical explosives implode ■ small core of fissionable material at the center. The energy released is used to compress a surrounding layer of hydrogen fuel, causing the atoms to fuse together to produce helium, energy, and ■ hail of high-speed neutrons. In a typical hydrogen bomb, these neutrons are absorbed by a uranium casing of fissionable material surrounding the device. This causes the casing to fission, resulting in an even bigger explosion, releasing even more heat and radiation and still more fallout.

In the summer of 1958, Sam Cohen, ■ strategic nuclear weapons analyst at Rand Corp., a military think tank in Santa Monica, Calif., began investigating the military possibilities of large thermonuclear warheads. During his research into the possible effects on high-flying bomber crews, he became impressed by the high neutron release accompanying the fusion reaction.

He reasoned that if the outer uranium casing of a hydrogen bomb were removed, the neutrons released would travel great distances. Such neutrons would be capable of penetrating relatively well-shielded structures with lethal doses and incapacitating the people inside. Since fallout is due primarily to products of the fission reactions, removing the outer casing would leave only the initial small fission reaction, releasing only one-hundredth the radiation of a comparable fission weapon. Even so, the weapon would emit a large percentage of neutrons, making it considerably more deadly than ■ standard atomic or hydrogen bomb. Thus the enhanced radiation weapon (ERW) or neutron bomb was born.

The concept of a weapon that could kill people but leave most structures intact had great appeal for some in the armed forces and government. When the idea was first proposed during the 1960s, the Kennedy administration decided against building neutron weapons because it might jeopardize the nuclear test moratorium that the United States and Soviet Union were currently observing. But when the Soviet Union broke the moratorium in 1961, this barrier was removed and by 1962 the first neutron device had been successfully tested. ERWs became an on-again, off-again item until the mid-1970s, when the Carter administration proposed modernizing the U.S. nuclear arsenal by installing neutron warheads on the Lance missile and artillery shells planned for deployment in Europe.

There were many who felt that the weapon, because of its relatively small blast and fallout, was ideal for use in densely populated Europe against ■ Soviet tank attack. Such a weapon could penetrate the armor of attacking tanks and hardened structures, killing the people inside while limiting other damage. Others contended that deployment of the neutron warhead should be kept as a bargaining chip against the new Soviet SS-20 missile, seen

(Continued on p. 22)

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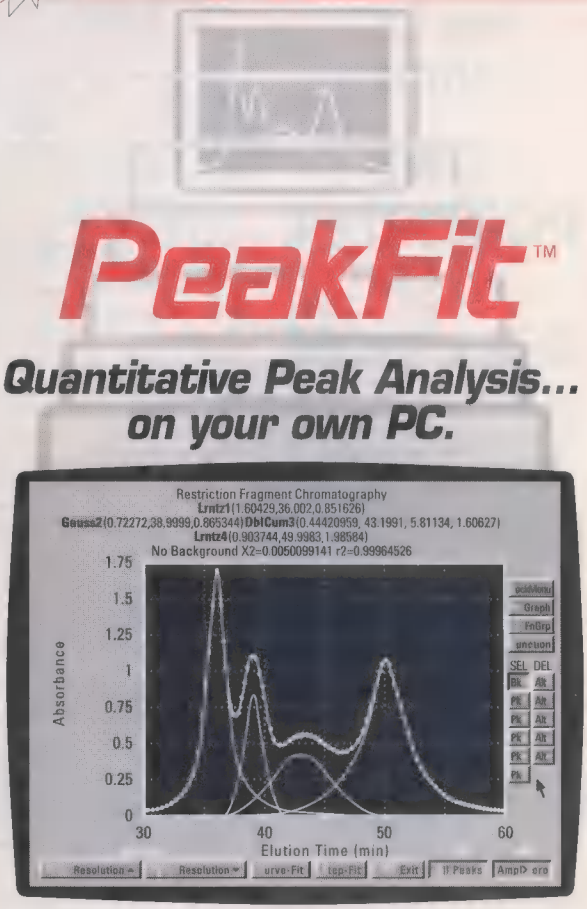
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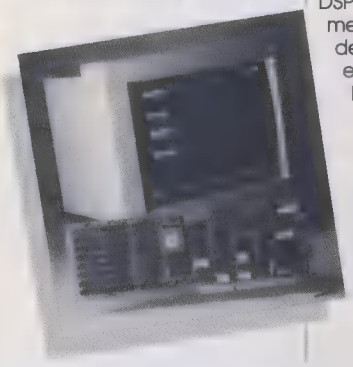
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WHATEVER HAPPENED TO

(Continued from p. 20)

as a threat to the North Atlantic Treaty Organization (NATO) forces in Europe.

Others felt that the neutron bomb would make the unthinkable thinkable. The complete destruction that nuclear weapons would bring was the primary deterrent to their use. The neutron bomb, on the other hand, could conceivably make nuclear war more possible by allowing the use of nuclear weapons without inviting wholesale devastation of the target, it was argued. Military planners might not be as hesitant to use neutron weapons as they might a standard fission warhead.

The ensuing political turmoil shook NATO to its core. The debate over the deployment and use of ERWs was as heated in Europe as it was in the United States. In 1977, West Germans, realizing their country was the most likely battleground for such weapons, began hotly debating whether or not to allow such weapons on their soil. Similar political battles raged in other NATO countries. President Carter, bowing to domestic and international pressure, decided in 1978 to defer deployment of the weapon, conditional on Soviet restraint in military production and force deployments.

In August 1981, President Reagan fueled the political debate again by re-authorizing the production of neutron warheads for the Lance missile and an 8-inch artillery shell. Because of strong opposition from Western Europe, Reagan ordered all neutron weapons to be stored in the United States, with the option to deploy overseas in case of war. The USSR publicly announced that while it, too, had tested neutron weapons, there were no plans to deploy them.

In the meantime, the deployment of neutron weapons in Europe had become more complex as other players joined the game. In 1980, France announced that it had tested a neutron device, and in late 1982, it was believed to have begun production. But in 1986, France announced that it was abandoning the production of neutron weapons because of internal and external political pressure.

The current status of neutron weapons is something of a mystery, though. The U.S. nuclear arsenal is still believed to contain some 350 neutron warheads for the Lance missile and a similar number of 8-in. artillery shells. As the thawing of the Cold War makes their primary function—defense of Europe against a mechanized armor attack—even less likely, the possibility of their use becomes even more remote. The current antinuclear climate gives little hope that NATO allies would ever consent to their use in Europe.

In addition, the United States confronts a two-year-old interruption of tritium production at the Savannah River Plant in Aiken, S.C., the United States' sole source of tritium production. So the fuel used for these warheads will most likely be withdrawn and used elsewhere.

Coordinator: Kevin L. Self
Consultant: Stan Norris, Natural Resources Defense Council

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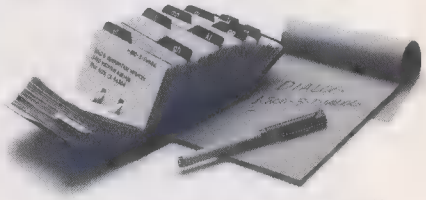


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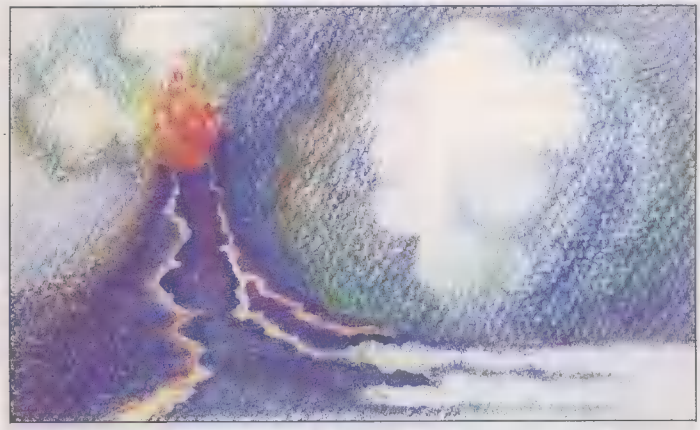
First came fog, then smog, and now *vog*

When a volcano erupts in a fiery fury, residents of nearby areas are evacuated from the paths of molten lava so they can avoid the fate Pompeiians shared in the 1st century. Now *vog*, or volcanic fog, may be another reason for people to flee the wrath of Pele.

Since 1986, continuous eruptions from the eastern rift of Hawaii's Kilauea volcano have sent streams of lava flowing into the ocean, creating explosions of steam and a highly acidic plume cloud.

Vog, a portmanteau word like smog, was coined by volcanologists in recent years by combining *volcano* and *fog*. It is now linked to such health problems as bleeding of the nose and gums and influenza-like inflammation. And in the form of natural acid rain, it also likely damages the environment by increasing the concentration of metals in the soil and water. This kind of acid rain contains hydrochloric acid (whereas industrial acid rain contains sulfuric and nitric acids).

Three researchers, Terrence Gerlach, who is now at the U.S. Geological Survey (USGS) Branch of Igneous and Geothermal Processes in Denver, Colo., James Krumhansl of Sandia National Laboratories' Geochemistry Division in Albuquerque, N.M., and Robert Fournier of USGS in Menlo Park, Calif., have developed a theory of how natural acid rain forms.



Cathy Wassylenko

Their analysis of the plume revealed it to be an acidic brine with 2.5 times the concentration of salts found in seawater plus several thousands of times the usual concentrations of aluminum, iron, manganese, and silicon.

Gerlach and Krumhansl believe that when seawater meets lava, it is flash-dried locally, and the resulting salts react with steam to produce hydrochloric acid. The steam explosions then blast the brine and acid vapor into a plume cloud.

Incorrigible *engineerese*

A reader, Leon C. Pickus, wrote to bewail the following sample of *engineerese*: "The last receiver began assembly."

He commented: "Why isn't it 'Assembly of the last receiver began'? The faulty construction must be obvious; the 'receiver' is hardly capable of assembling itself (or has manufacturing technology reached a new plateau?)."

After 35 years of trying to correct such awkward statements, Pickus has admitted defeat. "The entire engineering world seems to be right and I'm wrong (for fighting it, at least)," he wrote.

That brings us to the term *engineerese*. The suffix *-ese*, according to *Webster's Ninth New Collegiate Dictionary*, when appended to the name of a particular place or country, refers to a nationality, a native, or a language, such as Burmese, Chinese, Japanese, or Siamese. (For some reason, Asian regions are favored with this suffix.)

A second definition refers to "speech, literary style, or diction peculiar to (a specified place, person or group)," usually in words applied in a disparaging sense, such as *journalese*. Unlike *journalese*, however, *engineerese* has not found its way into Webster. Surely, it is just a matter of time.

Engineer: whence thy name?

In days of yore when knights in shining armor rescued fair damsels trapped in castle turrets, the rescue effort probably owed more to engineers who designed battering rams to break down fortress gates than to the valor of the knights. Military engineers later built such engines of war as cannons and armored cars, and hence the name.

Leonardo da Vinci, the Renaissance artist and scientist, was also a military engineer. In his twenties, he offered his services to construct field bridges, mortars, and engines. Among those of his papers preserved in *Codice Atlantico*, now kept at the Biblioteca Ambrosiana in Milan, Italy, is a drawing of a giant crossbow operated by people about a tenth its size.

Later on, when engineering talent was applied to nonmilitary uses, like building bridges, roads, and dams, the term "civil engineer" was devised to differentiate this kind from the military engineers.

According to Webster's, an engineer is a "person who is trained in or follows as a profession a branch of engineering." Engineering is defined as the "application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to people in structures, machines, products, systems, and processes."

In today's increasingly specialized world, the profession has splintered into a variety of disciplines: aerospace, biomedical, ceramic, chemical, civil, computer, electrical, industrial, materials, mechanical, mining, nuclear, ocean, textile, and so on. Each discipline further subdivides itself into more subspecialties.

The variety bewilders the mind. And the list does not even include "locomotive engineer" and "sanitary engineer."

The haves and have-nots

At what point does a country arrive and join the club of industrialized nations? Why are some merely "industrializing" and not industrialized, such as the four Newly Industrializing Countries—South Korea, Taiwan, Hong Kong, and Singapore?

Elsewhere, countries have been conveniently classified as industrialized, communist, or Third World. Alternatively, they have been labeled developed, developing, and underdeveloped.

The World Bank, in its *World Development Report 1990*, groups economies according to their gross national product (GNP) per capita. Instead of the category "developing economies" that it used last year, the World Bank is using the terms *low- and middle-income economies*. Countries with ■ GNP per capita of US $545 or less in 1988 are *low-income economies*, while those with a GNP of more than $545 but less than $2200 are *lower-middle-income*. And those with a GNP equal to or more than $2200 but less than $6000 are *upper-middle income*. Finally, those with a GNP of $6000 or more are *high-income economies*.

By this definition, then, Hong Kong, Israel, Kuwait, Saudi Arabia, Singapore, and the United Arab Emirates—countries (or geographical entities) classified either by the United Nations or their own governments as having developing economies—have joined the club.

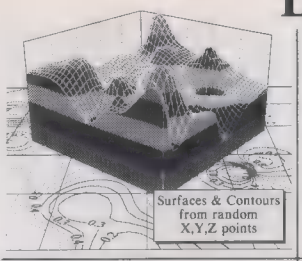
The United Nations Developing Program (UNDP), a funding agency that works toward improving agriculture, education, health, and technology transfer, uses the terms *developed*, *developing*, and *least developed*.

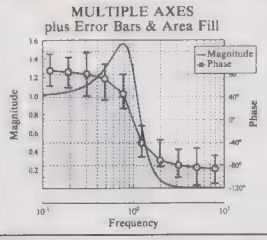
Developed countries are those in Western Europe and the United States, Canada, and Japan. The last one to catapult into the developed country club was Spain in the mid-1970s. Least developed countries are those with a GNP per capita of less than $200 (for 1990), ■ low life expectancy (where residents rarely reach age 60), and ■ population where less than 20 percent have ■ primary education. Other factors such as drought, desertification, ■ high-debt service, and being landlocked are taken into account. Developing countries make up the balance. Most of UNDP's funds are allocated to the least developed countries, 42 in all.

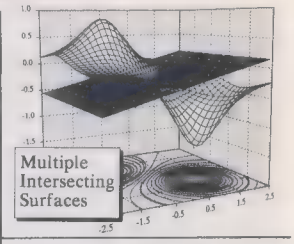
With the Communist Bloc all but gone, the former Eastern Bloc nations will have to be reclassified. After some debate, UNDP decided that Eastern European countries will remain categorized as developing countries.

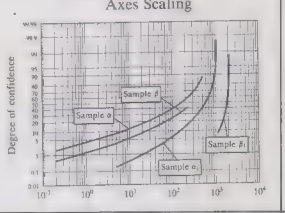
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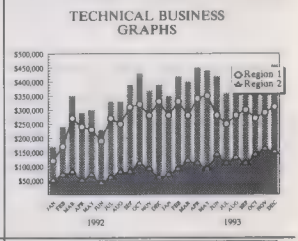


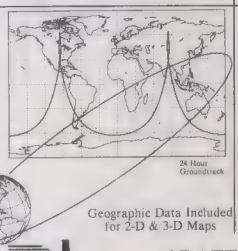




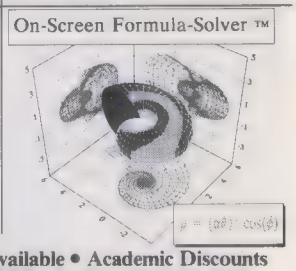
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Toward higher quality

All salespeople tell their customers that their company's products and services are of the highest quality. All chief executive officers wish they were right.

One executive who can be sure his firm's salespeople are right most of the time is Motorola Inc.'s chairman Robert Galvin. Motorola was the first major corporation to win the Malcolm Baldrige National Quality Award, a recognition the U.S. Department of Commerce initially bestowed in 1988.

Those of us who worked for component manufacturers that were suppliers to Motorola were hardly surprised at the award. Quality is not a new concern for the company. Even in the 1950s the consumer electronics division at Motorola was known as the toughest taskmaster on incoming inspection and quality levels. The company was one of the first to inspect and monitor production lines of its suppliers. Indeed, a visit to a supplier by Motorola personnel was anticipated with some trepidation.

So when Galvin addressed a Wescon audience last November, no one was surprised to hear that Motorola has required all its suppliers to enter the Baldrige Award competition. They don't all have to win it, said Galvin, but they've got to try!

A spokesman from Motorola recently said that when the Baldrige competition was announced, the company was poised to compete; no unusual efforts were needed because of the effective quality-control procedures already in place.

When Xerox Corp. won the Baldrige Award a year later, the situation was different. The company had not been satisfied with its quality levels, Paul A. Allaire, Xerox president and chief executive officer said, and had targeted major improvements. It set up goals and procedures and a "National Quality Office" to pursue its objectives and, concomitantly, the Baldrige Award. The cost was significant. Related office expenses alone in 1989 approached US $1 million. And Xerox now presents quality seminars around the country, a practice that stemmed from its winning the Baldrige Award.

We recently heard of a CEO who approached his board of directors to gain its approval to mount an effort to improve quality of the organization's products and services, with an eye toward also entering the Baldrige competition. The Board voted its approval, with the proviso that no company funds were to be spent in the effort. We think it unlikely the company will make much of a dent in quality improvement; nor will they probably be able to even position themselves to try for the Baldrige Award.

Quality comes at a cost. The organization that will not pay for quality will not achieve it. And, perhaps, it will not survive.

More on elegant design

Recently we commented on the topic of elegant design [June 1990, p. 19], by which we meant, echoing the words of Webster's Third, design having the qualities of scientific precision, neatness, and simplicity. Aren't there good examples of elegant electronic design, we asked, and proffered the ferrite-core memory, the flip-flop, and the negative-feedback circuit as candidates. We also cited examples from other disciplines, most of them consumer-directed—like the Zippo lighter, the Milk-Bone dog biscuit, the Oreo cookie, and the paper clip. (We failed to mention the wheel, the axle, Post-it Notes, and the stuffed olive.)



Readers did not disagree with our selections and added a few of their own, like the Simpson 260 multimeter. We had also nominated several candidates that were more complex, and perhaps therefore inappropriate for the designation "elegant." For instance, we included the RCA 630 TV receiver. But remember, that set had 30 vacuum tubes, including the picture tube. A high performer, perhaps, but was it elegant?

Readers, rightly or not, followed our lead and nominated some fairly complex equipment. But they also included products that have outlasted their expected lifetimes. By extension, the New York City subway system might qualify; though few would call it elegant, perhaps its design is. Or maybe it has lasted simply because it was overdesigned.

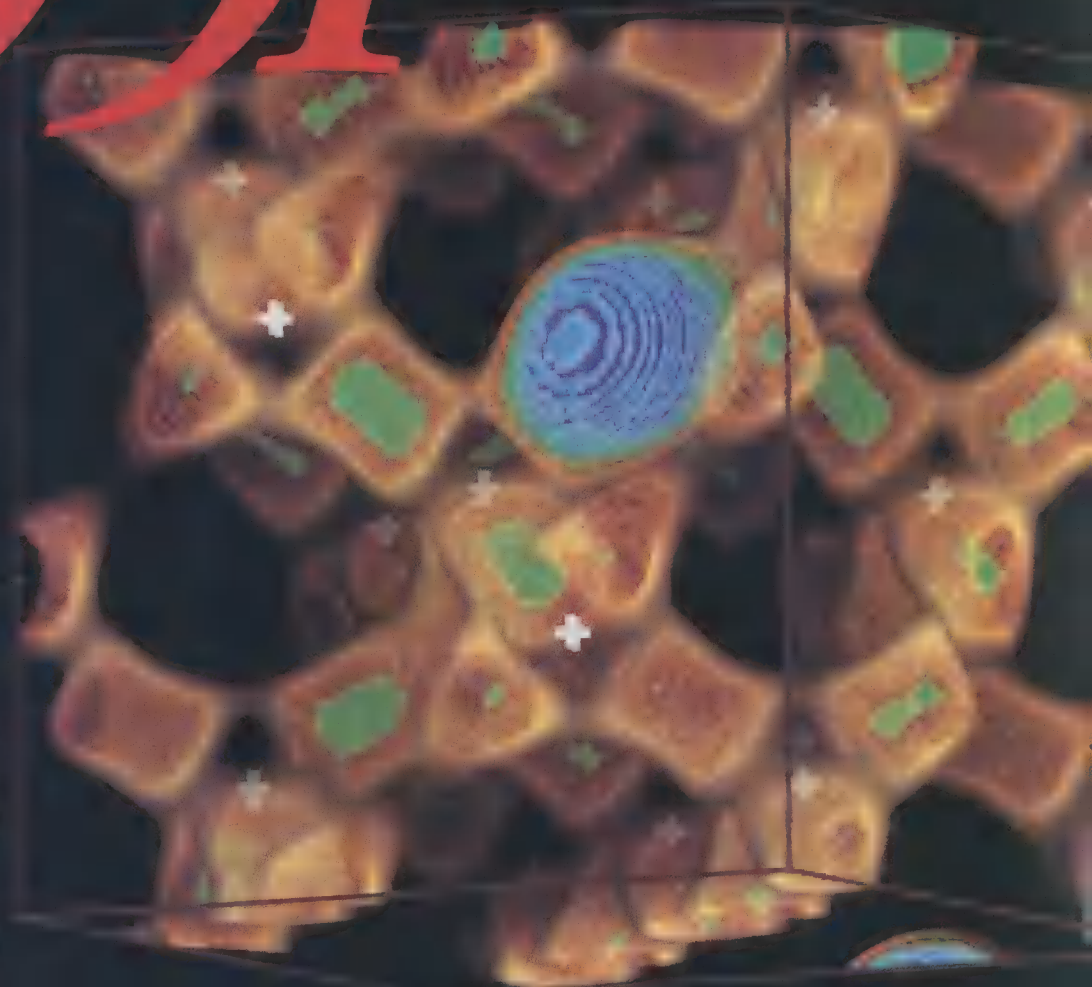
One good question concerns whether most elegant electronic designs are intentional or accidental. This raises the issue of whether such designs stem from inspiration or systematically applied perspiration, or both. Historians of innovation joust with such questions regularly, in a seemingly impossible attempt to characterize the process of innovation.

An exercise left to the reader is to judge the following as to their degree of elegance, and then to speculate on the amount of inspiration brought to each by its developers: frequency modulation, the push-pull amplifier, the triode vacuum tube, the transistor, the integrated circuit, the flip-flop, negative feedback, parity-bit checking, radar, single sideband, the electric-wave filter, and the planar process.

And a final challenge: can you identify an elegant electronic development (hardware or software) that was made in this decade (1980 to the present)? If you have trouble doing so, could it be that elegant designs are more difficult to come by as systems grow in complexity?

—Donald Christiansen

Technology 1991



A supercomputer generated this image of the electric charge inside a silicon crystal. The blue sphere is a single oxygen atom; it straddles one of the silicon bonds in the bonding lattice, represented by the yellow-brown honeycomb. The white Xs mark silicon nuclei.

IBM Corp.

This is *IEEE Spectrum*'s 18th annual hardware and software review. As in the past, we invited technical experts—this year in 13 areas—to discuss significant developments and burning issues in those areas. Staff editors, in the accompanying articles, identify specific technical developments, including manufacturers and equipment models where appropriate.

Among the insights from the experts:

- "The fact is that Unix-based systems are taking over [the desktop computer]."—Eric E. Schmidt
- "The increasingly popular concept of 'software reuse' will play an even larger part in maximizing productivity."—Eric Wagner
- In the computer industry, "maintenance of heterogeneous environments represents a trend toward recognizing and treating service as an important profit center."—Brad Friedlander
- "Communications freed from the tether of today's wired or cellular systems will yield an unprecedented level of flexibility."—Laurence B. Milstein
- "High-performance workstations and distributed-processing systems have increased the demand for packet networks with improved bit rates and response times."—Dipankar Raychaudhuri
- "Mass producers of semiconductors will have to streamline operations to survive in this decade."—Shojiro Asai
- "There must be a reduction of complexity so that users who are intelligent but not instrumentation gurus can cope with the design, installation, operation, and maintenance of the system."— Richard D. Thornton
- "The most important recent development [in industrial electronics] has been progress in the creation of microsensors, microactuators, and micromachines, all rapidly growing fields."— Ren C. Luo
- "For perhaps the first time in history, the possibility of war is exclusively linked to energy issues."—Henri Persoz
- "High-definition systems are core infrastructure technologies that cut across many industries."—Wayne C. Luplow
- "The TGV demonstration provides convincing evidence that high-speed rail can be developed beyond the current operational speeds of nearly 300 km/h."—Anthony R. Eastham
- "The current distress in the aerospace and defense industry may be the catalyst, so far lacking, to awaken the U.S. government."—Robert S. Cooper
- "As issues involving sustaining life are settled, the concept of quality of life is coming to the forefront of biomedical engineering."—Charles J. Robinson

Among the many developments noted by *Spectrum*'s editors:

- General Instrument Corp., San Diego, Calif., shook up the U.S. high-definition television race in the United States when it announced its all-digital DigiCipher system for transmitting a full HDTV signal in digital format over a standard 6-megahertz television channel.
- By the end of the decade, software systems and tools will bear little resemblance to those in use today.
- A combination of technical advances in magnetic resonance imaging is opening up new horizons for brain surgery.
- In the European power scene, major developments included the privatization of British utilities, the takeover of the eastern German antiquated power system by three western German utilities, and the Swedish Government's apparent retreat from a plan to abandon its nuclear power program.
- Computer-integrated manufacturing (CIM), fuzzy logic, and intelligent control are all contributing to greater manufacturing flexibility and reduced costs.
- Reduced-instruction-set computer (RISC) microprocessors remain controversial, although they are being applied in interesting ways.
- Dynamic RAMs are being shipped in volume in 4M-bit sizes; 16M-bit DRAMs are being sampled; 64M-bit devices have been demonstrated, and 256M-bit and even 1G-bit devices are in development.

Ronald K. Jurgen Issue Editor

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THE MAIN EVENT

Developers of the first working 64M-bit DRAM chip see it as a testbed for new circuits and fabrication concepts—and a demonstration of their company's strength

Halfway through 1990, Japan's Hitachi Ltd. surprised the semiconductor memory industry by announcing the first 64M-bit dynamic random-access memory (DRAM) on a single silicon chip. The company packed 140 million electronic components on a chip measuring 10 by 20 millimeters.

Hitachi's feat came at a time when the major memory manufacturers had just succeeded in getting 4M-bit DRAMs into volume production and were struggling to make 16M-bit chips in sample quantities for eager customers. Toshiba, Fujitsu, and NEC in Japan; Texas Instruments, Motorola, and IBM in the United States; Samsung Electronics in Korea; and Siemens in Germany are among those actively developing 64M-bit devices, but production quantities are not expected until about 1995, with sampling starting perhaps a year before then. By year-end, only Fujitsu had announced an experimental 64M-bit device, although papers on 64M-bit DRAMs from Matsushita Electric Industrial, Mitsubishi Electric, and Toshiba are scheduled for the International Solid State Circuits Conference this February.

Hitachi's Kiyoo Itoh, who has devoted most of his professional career to semiconductor memory development, led a group of 30 researchers and engineers in the Central Research Laboratory in Kokubunji, a Tokyo suburb. Working steadily for about 18 months, they used electron-beam lithography to define the fine, 0.3-micrometer-line CMOS circuits they needed. They shrank the size of the multilayer-capacitor memory cells to 1.3 square micrometers by using tantalum oxide as the dielectric instead of the usual silicon djoxide. (By way of comparison, today's 4M-bit DRAMs have 0.7-μm lines and about 8-μm^2 cells.)



Hitachi Ltd.

The prototype 64M-bit memory chip holds well over 100 components in its fingernail-size area. Its mass production for such products as notebook computers is expected in four years.

Problems solved

Itoh and his team are especially proud that their DRAM operates directly from a 1.5-V supply instead of the 3 or 5 V of smaller DRAMs. The low voltage, although ideal for portable, battery-powered computers, tends to become unstable in a 64M-bit chip, which presents four times the capacitive load of a 16M-bit chip. The rise time of the required current into the required load was so long that the generated voltage fluctuated wildly and memory access became hopelessly slow. The team's solution was to add a circuit that generates the load current with a small control current and keeps the generated voltage stable, even under wide load variations, by means of feedback. They report that the voltage now stabilizes 40 times faster.

The Hitachi researchers also developed a new kind of sense circuit to amplify the small voltages that memory cells produce on readout. Again, the problem was exacerbated by the 1.5-V supply; the readout voltage is low and it took time to build up an adequate signal. The new sensor circuit reduces the load on a cell and allows the signal voltage to be lower. The circuit reduces access time by 20 nanoseconds.

The combined circuit innovations gave the 64M-bit memory an access time of only 50 ns and power consumption of only 44 milliwatts. The access time is as good as, or better than, that of Hitachi's 16M-bit chip, and the power consumption is one-tenth that of the older device, according to Hitachi engineers.

Itoh recalls that a major problem he and his team encountered was depositing a reliable dielectric film for the memory cell capacitor. "The as-deposited tantalum pentoxide film turned out to have a large leakage current when the effective thickness, in terms of an electrically equivalent silicon dioxide film, was less than 3 nanometers. We developed a two-step annealing method to reduce the leakage current: annealing at 300 °C in ozone with ultraviolet irradiation, then dry-oxygen annealing at 800 °C." The team found that the annealed 3-nm film has a low leakage current as well as low defect density.

Another obstacle was the proximity effect in direct-writing electron-beam lithography: some electrons recoil at the surface under the resist and thereby change the size of the lithographic pattern. The Itoh team developed a correction method in which they classified patterns by size and adjusted electron-beam exposure accordingly; they were thus able to etch the fine detail of a 64M-bit chip with the necessary accuracy.

Criticism of Hitachi's announcement has not been lacking. Competitors contend that the announcement was premature, that only two-thirds of the cells actually functioned. Moreover, the three-year interval between DRAM generations is fixed by economics, not by technology, many believe; manufacturers need that time to pay for the R&D and tooling that went into the previous generation before they introduce a new one.

Criticism discounted

Hitachi engineers, for their part, have no doubts about the validity of their demonstration. "We are at the first step on the long way to production," Itoh told *IEEE Spectrum*. "Our prime concern at the first step is not only to make the first 64M-bit chip but also to try out many new concepts. Therefore our experimental chip was designed as a feasibility study. The quality of our chip is high enough to check feasibility."

Hitachi expects to go into volume production of its 64M-bit DRAM in 1995. Sample quantities will be available "a few years" before volume production, the company says. ◆

George Watson Senior Editor

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THE MEDIA EVENT

The Hubble Space Telescope's main mirror, stabilization system, and high-gain transmission antennas required engineering at a distance to compensate for flaws

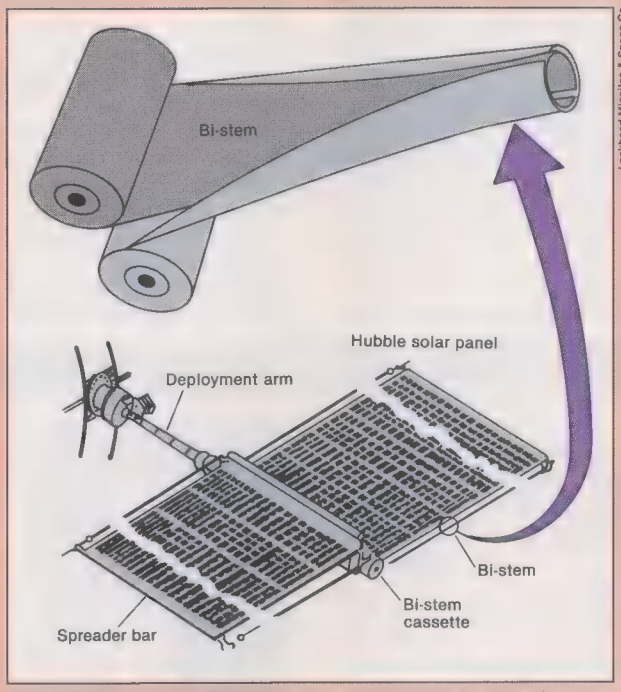
The front-page engineering story last year was the plight of the Hubble Space Telescope. Launched on April 25 into a 610-kilometer-high orbit, the US $2.5 billion spacecraft was to have been the most precise observatory ever built.

But on orbit the nightmare began. First, a loop of cable on one of the two high-gain communications antennas turned out to be improperly tied to the antenna's mast, limiting the time during which the antenna could transmit data back to earth. Next, the solar panels vibrated for 3–6 minutes each time the spacecraft passed into or out of sunlight, throwing off the sensors fixing the telescope on a guide star and disrupting the observation in progress. Worst of all, the telescope's 2.4-meter-diameter (94-inch) main mirror was found to have been ground and polished to the wrong shape and thus is unable to focus an image.

The first press reports reflected the astronomical experimenters' woes. Quotes were published claiming that over half the observations planned by the wide field and planetary camera (WF/PC, an acronym pronounced "wif-pic") were now impossible—including the planned "pretty pictures" of planets, galaxies, and other celestial objects.

Engineers at the National Aeronautics and Space Administration (NASA), the Space Telescope Science Institute (STScil), Baltimore, Md., and Lockheed Missiles & Space Co. Inc., Sunnyvale, Calif., the prime contractor, along with many of the principal astronomical investigators, rallied in emergency sessions to see what could be salvaged.

The antenna problem was relatively easy to fix. In late May, engineers uploaded a revised software patch that allowed separate control for each side of both high-gain antennas. According to NASA experts, now the antenna's only constraint on the telescope will be a little less flexibility in scheduling transmissions or observations requiring real-time control.



Lockheed Missiles & Space Co.

The Hubble Space Telescope's solar panels begin vibrating whenever the spacecraft crosses from sunlight to shadow in its 90-minute orbit around the earth. Thermal stresses in the long, thin, flexible support arms (bi-stems) that helped unfurl the solar-cell arrays are believed to be the cause. The bi-stems are formed from two flexible, semicircular ribbons that slide together as they extend from their storage cassette.

Prime focus

The mirror's blurry vision has been more of a challenge. Since the spherical aberration prevents the light from being brought to a sharp focus, every image is larger—and thus fainter—than specified. The dimming of the telescope's vision cripples astronomical observations of very faint objects.

Still, with bright objects the telescope's resolution meets the original specifications. Depending on the experiment and the instrument, image exposure times must be increased by 1.5–6 times to regain the intended signal-to-noise ratio. "This is the opposite of what's generally reported," said Ed Weiler, Hubble Space Telescope project scientist at NASA headquarters, Washington, D.C.

To enhance resolution, the NASA engineers have called on image processing. Using a mathematical technique developed in 1974 by L.B. Lucy of the European Southern Observatory, headquartered in Garching, Germany, they remove the fuzzy halos around the stars in unprocessed images, leaving only the bright cores. Even though the processed images are not of the same quality as those produced by proper optics, they already have led to some new astronomical discoveries and even such "pretty pictures" as the first observations of expanding gaseous rings around exploding stars and several spectacular views of the planet Saturn.

To compensate for the aberration in the main mirror over the long term, NASA is modifying the curvature or "prescription" of the lenses of an already planned second wide field and planetary camera (WF/PC-2), scheduled to replace the current one during a routine maintenance mission in 1993.

The most challenging problem now is damping the jitter that vibrates the spacecraft each time it passes into or out of the earth's shadow. The worst vibration has a period of about 10 seconds, or a frequency of 0.1 hertz.

In October, investigators at NASA and Lockheed uploaded software that would sense the onset of vibrations and create countervailing motions of the spacecraft's gyroscopes and flywheel-like reaction wheels to damp the jitter. Although the initial fix reduced the 0.1-Hz jitter thirtyfold, it caused the computer to command the reaction wheels to spin too fast, and created higher-frequency vibrations. Programmers were to have tried a modified software fix by the end of December. A permanent remedy under consideration is changing the solar panels, perhaps during the 1993 maintenance mission.

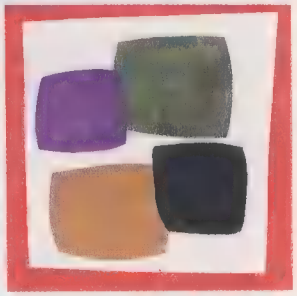
Worse yet, because the fine-guidance sensors are less sensitive than required by the specifications, the jitter sometimes prevents the telescope from maintaining fine lock on faint guide stars for the highest-resolution imaging. The condition makes it harder to tell how far off from a faint guide star the telescope is pointed. And during day-night jitter, the guide star may be lost and not readily reacquired.

On brighter stars, or in the guiding mode known as coarse track, however, the fine-guidance sensors perform better than specifications. All images so far have been obtained in coarse track. If the fine-lock problem cannot be solved, it will limit the number of objects the wide field and planetary camera can study. Engineers are fine-tuning the alignment of the secondary mirror and modifying flight software. ◆

Trudy E. Bell Senior Editor

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PCs AND WORKSTATIONS



Laptops, notebooks lead in growth
RISC computers break US $5000 barrier
PC plug-in offers workstation graphics
Floppy-disk drives top 20 Mbytes formatted

Keeping track of the many new workstations and desktop, laptop, and notebook personal computers that were unveiled last year was no easy chore. Power went up, up, up, while size came down, down, down, until the power of desktop computers was being crammed into the smallest machines.

The boundaries everywhere were becoming difficult to define. Indeed, the distinction between the engineering workstation and even the laptop PC was blurred even further by a laptop Tokyo's Toshiba Corp. deemed powerful enough to be billed as an engineering workstation. And the Sparc LT, AS1000/L10 became the first laptop to be based on ■ reduced-instruction-set computer (RISC)—through Sparc architecture developed by Sun Microsystems Inc., Mountainview, Calif.

Those who need to do finite-element analysis while traveling might want to consider the rather weighty 17.7-pound (8-kilogram) machine introduced last year. It features ■ workstation speed of 13.2 million instructions per second (MIPS), ■■ well as 8M bytes of memory, ■ 180-megabyte hard-disk drive, an active-matrix monochrome liquid-crystal display of 1152 by 900 pixels, and a 3.5-inch floppy-disk drive. However, it is still sold only in Japan for 1 980 000 yen (about US $15 000).

This was just one of a continuous merry-go-round of new product introductions. Included were many other laptops, as well as notebook-size machines. Together, laptops and notebooks composed the fastest growing segment of the personal computer marketplace.

For example, while all PCs sold through computer specialty stores in the United States increased at a modest 4.1 percent, to 2.2 million units for the first nine months of 1990 compared to 1989, laptops and notebooks leaped 60 percent, to 223 000 units, according to Egil Juliessen, chairman of Computer Intelligence, a market researcher in La Jolla, Calif.

Other notable announcements included a broad range of engineering workstations unveiled by Sun Microsystems. Among them was ■ diskless, Sparc-based machine for under $5000, ■ price that edged the machine closer to PC prices. Also, IBM Corp. brought forth its second entry into the workstation market, the new RISCSystem/6000, and Hewlett-Packard Co., Palo Alto, Calif., showed its first workstations in ■ merged HP/Apollo line—the HP Apollo 9000 Series 400 family.

Peripherals also spurred great activity. Hard-disk drives continued to get smaller while growing in capacity, and floppy disks jumped up to the "superfloppy" arena with an order-of-magnitude boost in storage capacity. And IC memory cards were on the verge of making their mark as replacements for rotating magnetic-disk memory.

Powerful RISC

IBM's RISC entries, introduced last February, comprised ■ family of four workstations and five servers. The company claimed several technical innovations for the Unix-based family, as well as for the industry's most powerful desktop workstation, the Powerstation 320, capable of 27.5 MIPS.

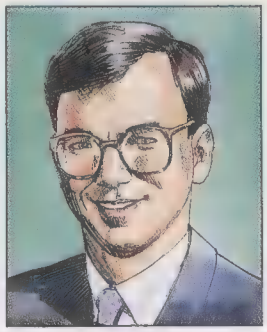
Power, an acronym for Performance Enhanced Optimization With Enhanced RISC, refers to IBM's second-generation RISC technology. This superscalar architecture separates the processor into three independent functional units—branch, fixed-point, and floating-point—that permit concurrent execution of multiple instructions.

Other noteworthy pieces of hardware announced by IBM included 3.5-in., 320-Mbyte and 5.25-in., 857-Mbyte hard-disk drives—with fast average seek times of 12.5 and 11.2 milliseconds, respectively—and ■ 32-bit Micro Channel bus supporting data rates of up to 40 Mbytes per second. The line also includes a "supergraphics" workstation, the Powerstation 730, which matches speeds of 34.5 MIPS and 10.9 million floating-point operations per second (Mflops) with graphics performance of almost 1 million three-dimensional vector transformations per second. The price of a Powerstation system starts at $12 995.

Plans were also under way to port Catia, IBM's highly regarded flagship computer-aided design/computer-aided manufacturing (CAD/CAM) and computer-aided engineering (CAE) software, to the System/6000 workstations. "When software support ramps up, the family will have a significant effect on the workstation industry," Bruce L. Jenkins, vice president at Daratech Inc., a market research firm in Cambridge, Mass., told *IEEE Spectrum*.

Alfred Rosenblatt Technical Editor

WHY UNIX WILL WIN ON THE DESKTOP



ERIC E. SCHMIDT: EXPERT OPINION

'The fact is that Unix-based systems are taking over.'

It's trendy to say that the line between PCs and workstations is blurring. The fact is that Unix-based systems are taking over, and by the end of the 1990s, the market will clearly distinguish between two types of desktop computers: those that run DOS and those that run Unix. DOS machines will be purchased primarily as single-user systems for stand-alone applications. And in the long run, the only single-user machines —the only DOS machines—will be in people's homes.

Why is this? Because distributed, networked computing is profoundly changing corporations. People ■■ inherently networked: we inherently need to communicate with each other. And networked applications need Unix-based solutions, because Unix is the only multitasking, multi-user, multivendor operating system available today. It is the only choice for the next generation of distributed applications

In short, Unix is the closest thing the industry has to an open standard. Because AT&T Bell Laboratories made it freely available in source form in the 1970s, nearly all systems companies—including such major players as IBM, Apple, Intel, Hewlett-Packard, Sun Microsystems, Digital Equipment, Olivetti, Fujitsu, and Unisys—either base themselves on Unix or offer ■ form of it.

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Sales for the workstation market should have reached $6.5 billion in 1990 and are expected to climb to $20 billion in 1995, according to Bill Ablondi, vice president for new desktop strategies at market researcher BIS CAP International in Norwell, Mass. He also noted that as many as 60 percent of total desktop systems, which includes PCs and peripherals along with workstations, are actually upgrades and replacements; new purchases (from scratch) represent the rest. Ablondi expects the upgrades to capture from 75 percent to 80 percent of sales in 1993.

Edging into PC territory

Also in the workstation arena, the past year saw Sun Microsystems lay the groundwork for a push into the commercial market where IBM PCs and PC-compatibles are entrenched.

Sun broke the $5000 RISC workstation barrier in mid-May when it unveiled major additions to its Sparc family of workstations and servers. The barrier breaker is the diskless Sparcstation SLC, a 12.5-MIPS, 1.2-MFLOPS, and 7.6-SPECmarks machine for $4995. Resolution of its 17-in. monochrome display is 1152 by 900 pixels.

Sun breached another obstacle last year—the $10 000 barrier for color RISC workstations—and took a shot at a market segment dominated by DOS-based machines. The $9995, 15.8-MIPS Sparcstation IPC includes a 207-Mbyte hard-disk drive and a DOS-compatible, 3.5-in. floppy drive.

At the mid-range of Sun's line was the Sparcstation 470, a 22-MIPS, 3.8-MFLOPS, 17.6-Specmarks server with up to 10 gigabytes of storage at an entry price of $59 900. The server is meant both as a file or database server for commercial environments and as a computational engine for technical environments. The system is also available in a workstation configuration for 2-D and 3-D graphics applications.

According to Sun, more than 2000 products from third-party software houses had been developed for its Sparc systems—a fourfold increase in a year's time. This was more software than was available for all other RISC/Unix workstations combined, the company asserted.

But Sun was not the only Unix workstation vendor to lower its prices to the PC level. There was NeXT Computer Inc., Redwood City, Calif. Its NeXTstation computer featured 15-MIPS performance, a 68040 microprocessor, a graphical user interface, and a list price of $4995. This machine as well as a pair of color versions and an expandable high-end machine that can be used as a network server or desktop were the company's follow-on products to the highly touted, but not very successful, NeXT cube-shaped computer introduced in 1988 as a developers' and education machine.

At the introduction of the new computers last September, NeXT Computer Inc., started by Apple Computer founder Steve Jobs, claimed to have already received 15 000 orders for the under-$5000 machine. Among the machine's assets are a graphical user interface that simplifies things for the user, an object-oriented development environment that simplifies things for the software developer creating applications having graphical user interfaces, and strong multimedia capability.

Hewlett-Packard also had a new computer for below $5,000. Its entry-level desktop 12-MIPS Model 400dl lists for $4990 and is upgradable to 20 MIPS by substituting a 68040 for a 68030. Other new HP machines reach to 26 MIPS. All run both the Domain/OS of Apollo and HP-UX from Hewlett-Packard, which, in turn, are both fully compatible with AT&T's Unix system. HP also announced a new graphics family, the HP Apollo 9000 VRX.

The industry was also seeing the fruits of Sparc's being made an open system. Around 20 Sparc-compatible computers were shown off at the Comdex Show in Las Vegas in November, priced from $4000 to $10 000. These came from personal computer, rather than workstation, manufacturers, and have the manufacturing and distribution channels, pointed out Laura Segervall, an industry analyst of the workstation market at Dataquest Inc., Santa Clara, Calif. She noted that the units are being sold now as a hardware solution, rather than a system solution. Most will not be shipped until later this year.

Unix is available on all PCs today in one form or another. Within five years, all high-end 386 and 486 PCs will be running Unix with DOS emulation. When this occurs, the final "dumb terminal" applications will disappear. Will this be the death knell of the minicomputer? And mainframes? They won't go away: they'll become servers. We'll just stop using them with dumb terminals.

The other operating system in contention (more or less) is OS/2. Though OS/2 provides multitasking, it is still a single-user operating system. It will have some following because of the existing installed base of DOS applications. However, users are looking for open solutions—and OS/2 is not open, especially not since IBM recently took back primary control over it. The resulting perception of OS/2 as a proprietary solution will stunt its growth and limit it to the derivative market of DOS applications.

Besides pointing to the "threat" of OS/2, Unix foes have brought up other arguments. But they just are not valid anymore. For example:

MYTH: the Unix market is splintered.

FACT: we are down to two choices: Unix System V Release 4 and OSF/1. All the major computer companies have endorsed one or the other. OSF/1's sponsors say that it will be interoperable with SVR4, giving us as close to a single standard as possible without having a monopoly.

MYTH: there are no Unix applications programs.

FACT: the leading PC software applications—Lotus 1-2-3, WordPerfect, dBase, Ventura Publisher—are ported, or are in the process of being ported, to Unix. The combination of these applications and new distribution mechanisms based on compact-disk ROM (CD-ROM) will trigger an explosion in Unix use by former DOS users. CD-ROM is inexpensive and easy to use and stores up to 644 megabytes of information, making it a much more effective software distribution medium than floppy disks.

MYTH: Unix is hard to use.

FACT: Sun and other companies have created graphical user interfaces like Open Look that conceal the complexity of Unix, making it easier to install and use. DOS, of course, has been easier to use because it does rather little. It has no functionality, so it is not complicated.

MYTH: Unix will always be outdistanced by Macintosh OS and DOS.

FACT: although they currently have a larger market share, Unix is catching up. According to Unix International, Unix has more than 10 million users worldwide as well as the highest growth rate. There will surely be more than a million Sparc/Unix seats alone within the next few years, translating to more market opportunity for software developers and more innovative solutions for end users.

MYTH: Unix systems are too expensive.

FACT: a comparably equipped high-end PC now costs more than a Sun SparcStation, which unlike a PC comes standard with such useful features as Ethernet connection, large memory, and a monitor. And the cost of Unix systems will continue to drop. Unix is synonymous with "open," which is one reason why Unix—and the accompanying open systems movement—are revolutionizing the computer industry. The amazing events of the past year, with long-time proprietary vendors being pushed onto the open systems bandwagon, will only ensure Unix's ascendancy.

Eric E. Schmidt (M) is vice president, General Systems Group, at Sun Microsystems Inc., Mountain View, Calif. His group is responsible for the development and marketing of the company's high-end Unix workstations and servers. Prior to joining Sun, Schmidt was a member of the research staff at the Computer Science Lab at Xerox Palo Alto Research Center. He also held positions at Bell Laboratories and Zilog. He received a B.S. in electrical engineering from Princeton University, Princeton, N.J., and a Master's in electrical engineering and a Ph.D. in computer science from the University of California, Berkeley.

As workstation performance and distributed network computing both increased dramatically in the last several years, a widening gap developed between the workstations' processing power and the input/output performance of conventional Unix network servers. The result of that split is that requirements in I/O-intensive environments for file, database, communications, and computation servers cannot be met by these conventional file servers, according to Bruce Nelson, who is in charge of strategic planning for Auspex Systems Inc., Santa Clara, Calif. Generally, conventional servers have been high-end workstations or PCs or more expensive minis or mainframes—all retrofitted to perform the server function.

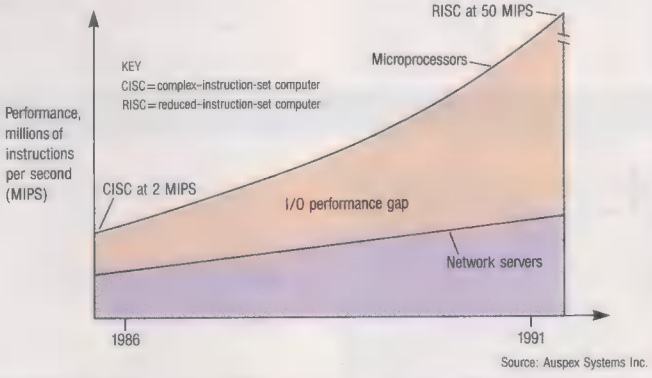
Thus, a new kind of network server established itself last year, one built around multiple processors and software tailored for the server application. Auspex, for example, has chosen to concentrate on Unix file and network servers, while NetFrame Systems Inc., Santa Clara, Calif., focuses on database servers for IBM PCs and compatibles. Auspex's NS 5000 server distributes network, file, and storage functions to dedicated processors—up to ten 68020-based processor boards for Ethernet, file, storage, and host processing. The server, with a starting price of $114 950, supports up to 100 diskless or about 200 dataless clients on eight Ethernets. A system supporting 100 clients costs about $2600 per seat, according to Auspex.

More powerful notebooks

In personal computers, one machine that attracted much attention when introduced last October was a 7.5-lb (3.4-kg) notebook computer from Compaq Computer Corp., Houston, Texas. It was built around a 20-MHz Intel 386SX microprocessor—the kind of central processor found in workstations and high-end desktops. The Compaq LTE 3286s/20 includes cache memory, a liquid-crystal VGA display, and 2.5-in. hard- and 3.5-in. floppy-disk drives.

The Model 60, at a suggested list of $6999, sported a 60-Mbyte hard-disk drive, while the $6499 Model 30 had a 30-Mbyte hard drive. Also available is a $1499 expansion unit that provides full 386SX desktop capabilities via a 14-in. VGA color monitor and an enhanced full-size keyboard.

Hardly had the news of this dandy been digested than Texas Instruments Inc., Dallas, about a week later brought forth its TravelMate 3000, a notebook computer that also features the powerful 20-Mhz 386SX. But at 5.5 lb (2.5 kg) and $5499 ($5999 with a 40-Mbyte, rather than a 20-Mbyte, hard disk), the TI notebook is lighter and cheaper.



An I/O performance gap has arisen in distributed computing networks as processor performance has outstripped the speed of conventional uniprocessor servers. Filling that gap is a new breed of multiprocessor servers made by Auspex Systems and others.

Last year, the two main PC contenders, IBM Corp. and Apple Computer Inc., also tried to expand their market reach by introducing redesigned computers and lower-priced machines. IBM's PS/1 family aimed at the home computer market. The price of Apple's new Macintosh machines, aimed at business, government, and education, as well as the home, was slashed by at least half. For example, the new Macintosh Classic incorporated many features of the Macintosh SE and carried a suggested list of $999, which included a 68000 microprocessor, 7-in. monitor, 1M-byte RAM, and 1.44-Mbyte, 3.5-in. floppy-disk drive. And the suggested list price of the color Macintosh LC with a 68020 chip was slashed 60 percent to $2499.

IBM was also aggressive in terms of personal computer marketing, with its most extensive Personal System/2 product rollout since that family's introduction in 1987. IBM's Entry Systems Division unveiled two of its most powerful personal computer systems, both high-end models incorporating Santa Clara, Calif.–based Intel Corp.'s 80486 microprocessor. At the same time, the company ended speculation about the next desktop computer graphics format by announcing a new high-performance graphics subsystem, the Extended Graphics Array (XGA).

Also included in that extensive product introduction were four other new PS/2 computers with more fixed-disk storage and performance, tape and disk drives, add-in display and memory cards, and a system enclosure for the peripherals. In addition, smaller (in memory) and faster releases of the OS/2 operating system were introduced. The systems all have a Small Computer System Interface (SCSI) through which seven peripherals—such as fixed disks, compact-disk read-only memory (CD-ROM) drives or tape backup—can be installed.

At the core of the new high-end machines—the desktop Model 90 XP 486 and the tower-style Model 95 XP 486 local-area-network file server—is a 33-MHz, Intel 80486 microprocessor. Instead of sitting on the motherboard, the central processor and its companion memory controller and memory cache option are on a plug-in board. This permits upgrades (of a 25-MHz machine, for example) via a simple board swap in what IBM calls its XP (Extendable Processor) system.

According to IBM, the two high-end machines are up to 2.5 times faster than the PS/2's older floor-standing Model 80-A31. Key elements in boosting performance are a hefty 256K-byte, 32-bit static RAM cache; dual 64-bit-wide memory paths; dual 64-bit-wide input/output controllers; high-speed disk caching; and a high-performance implementation of the Micro Channel architecture bus.

IBM's new XGA graphics subsystem handles resolution in the workstation range of 1024 by 768 pixels and supports 256 colors. This amounts to far higher resolution and faster graphics than the firm's 640 by 480-pixel Video Graphics Array (VGA) with its 16-color capability. The higher resolution is achieved while maintaining full compatibility with earlier IBM graphics standards, including Color/ Graphics Adapter (CGA), Extended/ Enhanced Graphics Adapter (EGA), and VGA. IBM also offered an XGA Display Adapter/A card as a $1095 plug-in for 32-bit PS/2 systems.

At about the same time late last October that IBM was making its PS/2 announcements, a long-time graphics workstation vendor was entering the PC world. Mountain View, Calif.-based Silicon Graphics Inc.'s IRISvision made its debut, the first real-time 3-D graphics boards for PCs with Intel microprocessors. The two-board set is meant for 8- and 24-bit color on Micro Channel- and AT-based PCs, using Intel 386- and 486-based computers. The set supports MS-DOS, Open Desktop (from the Santa Cruz Operation Inc. in California), and Windows 3.0 operating systems.

In addition, more than 20 PC and workstation software applications developers—15 with products already in hand—announced their support at the product introduction. This included IBM Corp./Cadam Group, Autodesk, Ithaca Software, Pixar, and Wolfram Research. The company hopes to have more than 100 software packages written or ported by the first year.

"IRISvision offers advanced features previously unavailable on PCs, such as real-time graphics manipulation," said Raj Parekh, vice president of Silicon Graphics' Personal Systems Di-

vision.

The boards—available this month in the United States, Canada, and Japan, and in the spring in Europe and the rest of the Far East—support resolutions of 1280 by 1024 and 1024 by 768 pixels, and is VGA-compatible. Suggested retail prices for the AT version of IRISvision/8 is $3495 and of IRISvision/24, $4995. The price of IRISvision/8 for Micro Channel is $3995.

The boards draw 90 000 3-D vectors, 14 100 triangles, and 9000 four-sided polygons per second. Such performance is equal to that obtained with a Silicon Graphics Personal IRIS workstation selling for about $13 500. (The company's workstations range from $10 000 to over $200 000.) The new boards, however, unlike the workstations, cannot be upgraded to higher performance if this becomes desirable.

Peripherals not idle

A new class of very high-density flexible, or superfloppy, disk drives made their presence felt during the year. The 3.5-in. floppy disks store more than 20 Mbytes of formatted data, an order of magnitude more than the 2 MBytes possible at the high end of conventional 3.5-in. floppies. Yet they are packaged in a standard 1-in.-high, 3.5-in.-wide (2.5 by 9 cm) form factor and aim at desktop, portable, and even laptop PCs.

Insite Peripherals Inc., San Jose, Calif., for example, showed off its model I325VM (variable mode) Floptical disk drive at November's Comdex Show. Insite first showed the drive about a year before, but modified it to also read and write to standard lower-capacity 1.44-Mbyte and 720-Kbyte diskettes. In addition to its use as the primary, or even the only, disk drive in a computer, the superfloppy could also qualify as a backup medium and as an aid for distribution of databases or complex software on a single disk, according to Chuck Moran, vice president of sales and marketing.

Indeed, enough interest was generated in the superfloppies—at least two other companies, Brier Technology Inc., San Jose, Calif., and Citizen America Corp., Santa Monica, Calif., have developed their versions as well—that a group of computer makers joined with the drive makers in November to try to establish standards for the media. In addition, IBM was said to be eyeing the superfloppy for use with its PS/2 computers, and was even soliciting bids.

Designed to plug and play with SCSI host adapters, the Insite unit goes into production next April. In volume, it will sell for $325 each, about the same as a 20-MByte, 2.5-in. hard-disk drive, pointed out Moran. Arrow Electronics Inc., Melville, N.Y., one of the world's largest electronics distributors, closed a nonexclusive deal to distribute the drive in the United States, Canada, and Puerto Rico. For Arrow, downward read/write capability was particularly important because it provides a bridge to existing floppies and software databases while the industry moves to the superfloppy's format.

A double-gap read/write head allows Insite's drive to read and write lower-capacity diskettes. One gap handles the Flopticals; the other gap, the standard diskettes. The Floptical's very high density is achieved by merging optical and magnetic recording technologies, including high-density barium ferrite disks, with low-cost components developed for compact-disk recording as well as for traditional magnetic-diskette drive assemblies.

Precise tracking of 1250 tracks per inch (490 per centimeter) is handled optically via a series of 900 concentric grooves, each 180 microinches (46 micrometers) wide, stamped into the diskette during its manufacture. This optical servo cannot be erased, and the media need not be as defect-free as others required for putting down a magnetic servo track must be.

HIGHLIGHTS

Success: Unix-based workstations from several vendors fell below US $5000 in price.

Shortfall: The new breed of Unix-based workstation manufacturer might be doing well, but old-line computer makers were turning up lots of red ink in marketing Unix workstations and large computers.

Notable: A plug-in board from Silicon Graphics Inc. for IBM PCs and compatibles allowed these machines to present the kind of high-resolution, two- and three-dimensional graphics that were available before only on Unix workstations.

Newsmaker: NeXT Computer Inc.'s Steve Jobs, who, two years after his first Unix computer flopped, brought forth a new trio that included an under-$5000 Unix machine capable of 15 million instructions per second that has multimedia capabilities and a graphical user interface. On the day of its press announcement, he already had orders for 15 000, he said.

2.5-inch hard-disk drives

Small, but high-capacity, hard-disk drives also saw a lot of action last year, particularly ones aimed at battery-powered notebook and laptop portables, and those used in emerging noncomputer applications in printers and facsimile machines. Quantum Corp., Milpitas, Calif., for example, unveiled a pair of its Go Drive Series of 2.5-in. units that provide 42 and 84 Mbytes of formatted capacity on one and two disks, respectively.

As personal computer makers shrink their machines, the game is being played out in fractions of an inch (or a matter of millimeters). For example, Quantum's single-platter 42-Mbyte Go Drive is 0.62 in. (16 mm) high, while its twin-platter 84-Mbyte unit is 0.75 in. (19 mm) high.

But Areal Technology Inc., San Jose, Calif., has a technology that lets it knock another millimeter or so off drive height. Its MC-2060 is just 0.59 in. (15 mm) high, yet packs 62.9 Mbytes of formatted data on a single disk. Areal's disk is unusual because it is made with a glass substrate. "These disks are flatter and smoother than conventional aluminum-substrate disks," explained Areal's vice president of engineering, Arnie Thornton. This allows the read/write heads of the drive to fly closer to the disk's spinning surface than with conventional disks, fostering higher data resolution and lower error rates.

IC memory cards

Plug-in IC memory cards got a big boost last year when a standard for physical size and data format was agreed upon by the PC Memory Card International Association composed of Japanese and U.S. memory card and computer manufacturers—"a noteworthy event because they came up with a standard before a lot of products were on the market," said Dan Sternglass, president of Databook Inc., Ithaca, N.Y., a manufacturer of the interface electronics for reading and writing to the cards. The advantage of the cards, especially for portable computers, is that they draw far less power than does conventional rotating memory.

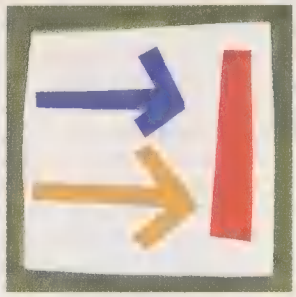
Databook introduced its TMB-200-03 ThinCard Drive to accept the new memory cards and their format. Poqet Computer Corp., Sunnyvale, Calif., for one, maker of the Poqet PC, a one-pound, MS-DOS notebook computer that accepts the memory card, said it would distribute the Databook drive through its own dealers.

The drive emulates, and fits into the bay of, a 3.5-in. floppy-disk drive. The ThinCard drives are made with any of a variety of standard and proprietary interfaces, and allow manufacturers to design memory cards into their computers. The drive makes it practical to transfer the information from an IC memory card in notebook or laptop computers to desktop PC/XT/AT units and compatibles.

The drive supports static RAM cards conforming to the new standard, and can program and read the various types of other cards that have been developed: one-time programmable; electrically programmable read-only memory (EPROM); and flash EPROM. Although data is stored in a different format in each type of memory card, a header is included to tell what chips are on the card and how data is organized.

Capacities of the cards ranges up to a 3M-byte SRAM, a 16M-byte ROM, and a 4M-byte flash EPROM. Ten- or 20M-byte cards may be available later this year, according to Sternglass, and a 64M-byte flash memory card is being planned in a venture by Intel Corp. and Tokyo's Fujitsu Ltd. Price of the cards range from $60–$80 for a 64k-byte SRAM card to $1200 for a 4M-byte flash memory. ◆

SOFTWARE



Unix settles into two camps
Windows 3.0 keeps DOS alive
OOPs and CASE get widespread support
Frameworks work and proliferate

A decade ago, only a few engineers would have foreseen being intricately involved with software by 1990. And nobody would have believed Nostradamus who foretold that, by 1990, Apples wouldn't just be for the teachers, all your Pets would be dead, mice would design ICs and computers, and the telephone company would extract gold by tapping into your computer operating systems.

So swift is the rate of change that software systems and tools 10 years from now will bear little resemblance to those in use today. Still, the overall direction seems clear: an ongoing battle among personal computer operating systems, the rise of object-oriented programming, the spread of computer-aided software engineering, and the proliferation of frameworks.

Last year, software wrapped up ever more tasks. Name just about any engineering function, and some kind of application software is available for it. Nor does it matter if the engineer's computer platform—"iron" to some software engineers—is a PC or a workstation.

The operating system and graphical user interface ["Open computing," below right] are the key elements of the application environment. If an engineeering team chooses the right operating system and graphical user interface (GUI)—in other words, those that have the necessary functionality and are openly defined as well as being widely accepted—then the group can ride the wave of applications advances and shoot the computer performance curls without wiping out. In the area of operating systems, there are three strong candidates from which to choose—OSF/1, Unix System V Release 4, and DOS with Windows 3.0—and a fourth whose future is not yet clear—OS/2.

Surf's up

In October, the Open Software Foundation, of Cambridge, Mass., hit the beach on which the Unix International Inc. consortium, of Parsippany, N.J., had held sway. The three largest computer companies—Digital Equipment Corp., IBM Corp., and Hewlett-Packard Co.—hung 10 on OSF/1, pledging full support of the Unix-like operating system.

That was a blow to rival Unix System V Release 4 (SVR4), developed by AT&T Co.'s Unix Systems Laboratories, Morristown, N.J., and Sun Microsystems Inc., Mountain View, Calif. Even so, SVR4 gathered still greater momentum in 1990, winning Hyatt Hotels Corp.'s US $12 million reservation system overhaul, for example. The Hyatt system uses SVR4 to perform on-line transaction processing on reduced-instruction-set computer (RISC) workstations from Pyramid Technology Corp., Mountain View, Calif. The job had formerly needed an IBM 4381 mainframe.

New companies extended Unix International's lengthy roster, too. In 1990, Apple Computer Inc., EG&G Idaho, Kyocera Corp., and The Mitre Corp. swelled the rolls to over 180 members, joining Cadence, Cray, Data General, Fujitsu, NCR, NEC, Texas Instruments, Toshiba, Unisys, and Xerox, among others.

Even so, OSF/1 cannot be written off. DEC, HP, and IBM command a mighty host of general business installations. Further, they dominate scientific and technology applications: in computer-aided engineering (CAE), DEC's DEC- and VAXstation, HP/Apollo's workstations, and IBM's RISC-based System 6000 are being widely supported with application software, and all three companies made important CAE announcements in 1990. (Sun, of course, also has wide support for its systems in CAE and therefore is seen as a threat by the trio.)

Thus the Big Three's support of OSF/1 augurs an operating environment that will unify all corporate departments: accounting, design, manufacturing, support, facilities management, and so forth. In fact, OSF/1 already has SVR4 playing technology catch-up. In its first release, OSF/1 will support symmetrical multiprocessing and distributed processing, as well as meet the B2-level criteria for system security defined by the Defense Department's National Computer Security Center.

AT&T's Unix Systems Labs says it plans to incorporate these features from the first half of 1991 on through 1992. Computer security was on the minds of many commercial as well as government users, this year, as ever more serious problems with malicious computer hackers became known.

In the realm of desktop Unix, the Unix-compatible Xenix of Santa Cruz Operation Inc., Santa Cruz, Calif., now dominates IBM-compatible PCs, and Apple is headed for SVR4 compatibility. Nonetheless, IBM said last year that it will bring its Unix-like AIX into line with OSF/1, and the workstation made by NeXT Computer Inc., Redwood, Calif., is inherently compatible because it uses the Mach OS from Pittsburgh's Carnegie Mellon University on which OSF/1 is based.

But even if the OSF/1 and SVR4 rivals agree upon one version of Unix this month (a virtual impossibility), the operating system battle would not be over. Corporate strategies must still take into account a DOS revitalized by Windows 3.0. Further, some

Spectrum *staff*

OPEN COMPUTING



ERIC WAGNER: EXPERT OPINION

'The increasingly popular concept of software reuse will play an even larger part in maximizing productivity.'

Vigorous discussion regarding standardization of computing environments (user interfaces, operating systems, and hardware resources) characterized 1990. Yet instead of consolidation, new graphical user interfaces are arriving at record pace. While consensus would appear to be desirable, the need to innovate is irresistible—and standardization is often the enemy of innovation.

A major revolution in graphical user interfaces (GUIs) is in process. Regardless of individual biases toward any one GUI, most people have come to agree that using one is better than not using one. The convenience of a ready-made user interface versus the tedium of reinventing the wheel weighed heavily with many developers. But the emergence of many new competing GUIs (add

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contend that OS/2 commitments by IBM and Microsoft Corp., of Redmond, Wash., must also be taken seriously, although others say its failure to attract substantial application support thus far makes it a non-issue.

Windows = Win/r

Windows 3.0 is an undoubted winner. From its May arrival through September, Microsoft had shipped 800 000 copies of the DOS-overlying software, easily outselling OS/2 with its Presentation Manager. Ensuring a warm welcome was a wealth of third-party software that made hay with the new Windows' vastly improved graphics.

Such popularity underlines the preference of PC users for an intuitive, productivity-enhancing graphical interface like the Macintosh's, not a DOS command line. Now that Windows embodies these features—long touted as assets by Apple in its commercials—Apple has brought the prices of its Macintoshes into line with the PC's.

But some PC users, notably corporations with 32-bit platform environments as well, want to know more about where Windows will fit in the OS/2 picture. For though Windows extends the usability of DOS, DOS remains a 16-bit system, whereas the 32-bit OS/2 lets applications address 4G bytes of memory directly and thus will forever outstrip DOS-run applications in speed.

On the other hand, a well-entrenched Unix makes it tough for another 32-bit operating system, such as OS/2, to appeal to independent software vendors and potential users. They need assurances that, at the least, OS/2 will be well supported, offer continuity for DOS/Windows applications, occupy less RAM than the first versions of OS/2, and have the device drivers needed to fit in a broad range of corporate applications.

IBM and Microsoft tried to allay those fears as 1990 drew to a close. The two companies, which have had difficulty working together, said they reached an agreement on supporting OS/2: Big Blue is to take care of OS/2 for its platforms, while Microsoft ports OS/2 to other systems (it is reportedly talking to MIPS Computers, for one). IBM said it will support Windows, OS/2, and Unix in its Officevision environment, and Microsoft began discussing plans for an interface between Windows and OS/2. IBM also unveiled OS/2 release 1.3, gratifying users' expectations with a less memory-hungry yet still high-performing system.

But does the world need two 32-bit operating systems: Unix and OS/2? These days, after all, companies can make their PCs Unix-compatible, maybe by using Xenix software from the Santa Cruz Operation (a spinoff of Microsoft, which still retains a 20 percent interest) or by running DOS applications in Unix shells.

For OS/2 to catch up on Unix-like systems in networked corporate environments, it will have to, in short order, mature rapidly, offer unique and valuable capabilities, and rally extensive support from independent software vendors.

Further darkening the OS/2 outlook are Microsoft's ambitions for Windows as the basis for multimedia computing, in which video, animation, sound, text, and high-quality photographs are seamlessly combined to teach, sell, and entertain. The multimedia market has yet to be defined: the debate still rages over the best way to combine various media for user friendliness; and the first tools for developing multimedia presentations are just reaching the hands of potential developers.

Microsoft also paints a picture in which Windows will link information with the programs or tools used to manipulate it, so that people can work more efficiently. Take the case of a newsletter being put together on a desktop publishing system by a graphics artist (among others) who wants to use an airbrushing tool for a last-minute fix on a photograph already in position on an electronic page. If information and tools were linked, the artist could just call the page to the PC screen and, by placing a mouse-driven cursor on the photo, start an airbrush tool from a pull-down menu. Once the photo is selected by the cursor, the system knows what tools can be used to manipulate it.

For PC users inured to starting an application (such as a text editor) before selecting the information to be processed (text), this speeds the work enormously. Macintosh users, however, will have this capability this year with the release of System 7. And while future versions of Windows may incorporate the capability directly, PC users can obtain it today by using NewWave for Windows 3.0 introduced by Hewlett-Packard last year.

HIGHLIGHTS

Success: Microsoft Corp. introduced Windows 3.0, a graphical user interface for IBM-compatible personal computers, in May and it was quickly accepted, both by users and independent software vendors.

Shortfall: In the battle for engineering frameworks, Mentor Graphics Corp. was forced to reschedule the release of Falcon 8.0 from November to the first quarter of 1991, while also delaying its move to Sun Microsystems Inc.'s platforms.

Notable: Major computer companies—among them Digital Equipment, Hewlett-Packard, and IBM—backed computer-aided software engineering and object-oriented programming with new products and alliances.

Newsmakers: Microsoft's introduction of Windows, which strained the relationship between it and IBM in developing OS/2, leading to a redefinition of company responsibilities for OS/2 and further hampering its acceptance.

Motif, NextStep, OpenWindows, and Windows 3.0 to the list of DecWindows, MacMultifinder, Presentation Manager, and the X Windows System) means that we may all need to become comfortable with a plethora of at times conflicting standards.

Additionally, with networking and distributed computing on the rise, we will need to be able to conduct our business across many different computing environments. The multitude of offerings will generate not only radical differences among customer sites but also, as speedier platforms and foxier GUIs are unveiled, ever greater heterogeneity among the computing environments at individual sites.

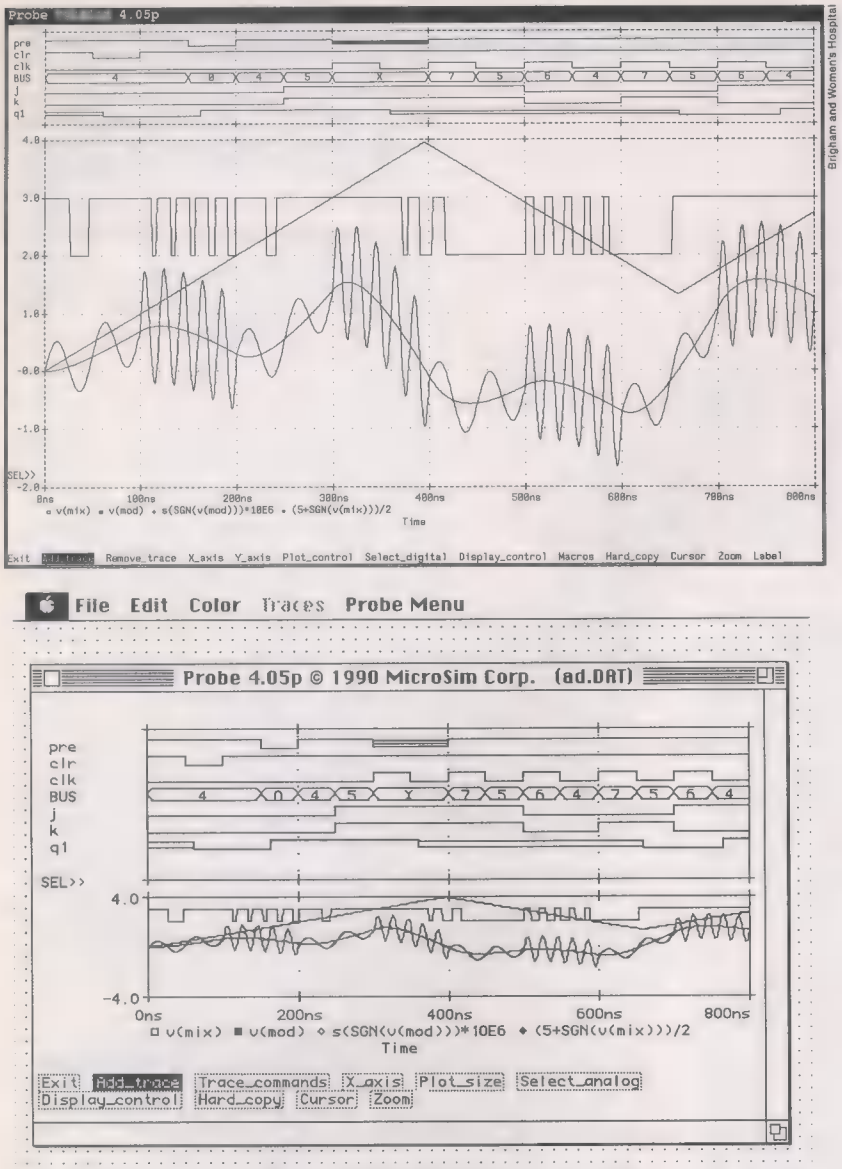
Over the last year, all these forces helped advance the concept of open computing—the idea that software should function on whatever system the user happens to have. As in the past, though, software makers have had difficulty keeping pace with the development of new hardware platforms and GUIs. In addition, users want smarter GUIs—and that entails software of greater complexity.

Instead of frustrating the emergence of innovative technologies, we should be advancing them through high-level software development tools that enable rapid software development across heterogeneous environments and so permit expansion of productivity in step with hardware innovation. The increasingly popular concept of software reuse will play an even larger part in maximizing productivity by allowing designers to draw on finished modules.

Many organizations have already begun to set up a central software library or similar central resource. Moreover, developers will want to be able to tap quickly into ready-made software building blocks, such as advanced menuing systems, advanced graphics systems, and miniature application libraries. With these blocks, they can incorporate entire subsystems with minimal effort. If these blocks are completely portable across computing systems and GUIs, they will also facilitate rapid and inexpensive transition to new, or additional, platforms.

Over the next few years, the growing complexity of software development will signal farewell to the development by one organization alone of a substantial application from scratch. The most innovative and successful software development will instead be done by two types of organizations: those capable of producing specialized tools and building blocks, and others who use those tools and building blocks to create effective applications. Only by specializing in one of these areas will companies be in a position to compete.

Eric Wagner is the vice president of product development for Ithaca Software, Alameda, Calif., a vendor of systems for developing interactive graphics software for personal computers and workstations.



Providing a consistent graphical interface to an application reduces relearning time when the computer system is changed to provide higher performance. For example, the analog simulator PSpice appears basically the same to a user whether it runs in a Sun environment (top) or on a Macintosh platform (bottom).

OOP and away

NewWave's talent for meshing data and applications in a single entity stems from its developers' use of object-oriented programming (OOP). OOP's premise is that a program is built of objects composed of data and processes. A so-called child object can inherit characteristics from parent objects; for instance, a newsletter can be a child that inherits characteristics from four parents: a text processor, an illustrator, a photographic manipulator, and a page-layout parent.

Object-oriented paradigms are ideal for developing graphical user interfaces (GUIs), where data and functions are called and activated at the click of a mouse button. Lab Windows, from National Instruments Corp., Austin, Texas, was one of the first technical software packages developed using OOP techniques and won many hearts in engineering and scientific circles.

The major computer companies lined up behind OOP en masse last October at the Oopsla (Object Oriented Programming: Systems, Languages, and Applications) Conference in Ottawa, Canada. Digital showed its Trellis Object System for programming and is supporting Objectivity Inc.'s Object-Oriented Database Management System (OODBMS). Objectivity, a Menlo Park, Calif., member of the electronic design automation world's Computer Framework Initiative, already has OODBMS porting to HP, Sony, and Sun platforms, as well as to 386-based PCs.

At the conference, which drew in excess of 2100 attendees, HP demonstrated C++ compilers (running in its CASEdge environment), as did Sun Microsystems and Apple Computers. An extension of C that incorporates object-oriented paradigms, C++ is now the most widely supported OOP language. AT&T's Unix Systems Labs took the Oopsla opportunity to announce the C++ Reseller Alliance, an organization that intends to do for AT&T's version of C++ what Unix International is doing for Unix. At its introduction, the organization had 15 members, including Apple, Sun, the Santa Cruz Operation, NCR Corp., Dayton, Ohio, and Solbourne Computer Inc., Longmont, Calif. Any company that licenses or distributes AT&T's version of the language can become a member free of charge.

In OOP, C++ has overshadowed Smalltalk in the last two years, but now Smalltalk, the first object-oriented language, seems to be undergoing a revival. For example, NCR switched development of its Open Architecture Test System (a test generation environment launched last year) from C++ to Smalltalk because engineers found the latter easier to work with.

IBM is using Smalltalk/V from Los Angeles' Digitalk Inc. to prototype OS/2 Presentation Manager applications and to develop interfaces for them. It is developing tools for OS/2 Presentation Manager jointly with Digitalk. It has also signed a licensing agreement with ParcPlace Systems to use Objectworks/Smalltalk Release 4—the Mountain View, Calif., company's version of the Smalltalk language—which should be available on IBM's RISC System/6000 next month.

CASE in point

The interest in, and availability of, new tools for creating OOP software were evident at Oopsla, underscoring the new seriousness about CASE. Until recently, few outside the programming sector had heard of CASE—the earliest known use of the acronym dates to 1984. However, following IBM's September 1989 unveiling of its AD/Cycle strategy for supporting CASE, Wall Street turned its attention to defining the market and discovered that it was growing far faster than business in the rest of the software industry.

According to Paul I. Bloom, a vice president at the San Francisco investment-banking concern Volpe, Welty & Co., the overall CASE market should double by 1993 to US$ 5 billion from last year's $2.3 billion. In what he defines as the technical CASE portion of that market—where companies like Cadre Technologies, Interactive Development Environments (IDE), Ready Systems, and Integrated Systems are the major players—Bloom predicts growth will more than double, from $150 million to $385 million.

"The CASE market now appears to have begun traversing the steep slope of the 'S' curve of new market development, moving from the early adopters to broader implementation," Bloom observes.

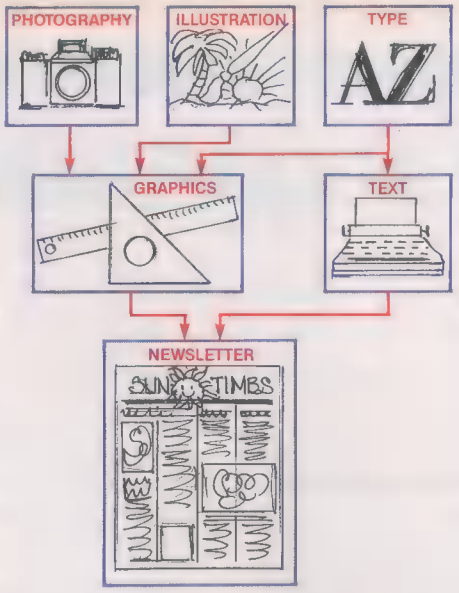
Working to leverage their respective strengths in hardware and software, Cadence Design Systems, San Jose, Calif., and Cadre Technologies Inc., Providence, R.I., agreed in June to integrate their technologies so that software and hardware could be co-

developed in a top-down approach and easily integrated. (The two have also agreed to support Digital's PowerFrame framework.)

Under its Cooperative Software Program, IBM will market CASE products from Atherton Technology Inc., Sunnyvale, Calif. Atherton's Integrated Project Support Environment (IPSE) consists of Software BackPlane—a framework for linking CASE tools, data, and methodologies—and the SoftBoard Series—tools for front-to-back-end support of software development and management. IPSE runs under IBM's AIX and is available on RISC System/6000 platforms, which are also popular in the electronic design automation (EDA) market. Atherton also has a technology exchange pact with Digital and supports the latter's VMS and Ultrix operating systems.

For now, IBM and Digital are disinterested champions of the CASE approach. They are willing to advise customers to adopt CASE and to advocate that they use tools from other parties. But that could change if either were to acquire a CASE operation.

Other companies—Hewlett-Packard and Mentor Graphics, for example—have opted to tackle CASE in different ways. Until 1990, HP's CASE products ran only on its platforms. To broaden its CASE base, HP decided last year to license the core technologies of its SoftBench and Encapsulator products so that customers could use other computer environments.



In the object-oriented paradigm, a newsletter may be considered a child object that inherits functional characteristics from its parent objects: graphics and text. The latter pass along functional characteristics they in turn have inherited from photography, illustration, and type. All these objects would be part of the general class, publishing.

Erecting Frameworks

The CAD Framework Initiative Inc. made good on its 1989 promise to link electronics design automation (EDA) tools. At last June's Design Automation Conference in Orlando, Fla., the Boulder, Colo.–based consortium of vendors and users of EDA tools demonstrated the CFI procedural interface (PI), which allows producer tools to transfer design data to consumer tools using netlists in PI format. Widespread support of CFI was evidenced by the number of companies participating in the demonstration; among them were AT&T Bell Laboratories, Cadence Design Systems, Computervision, Engineering DataXpress, GenRad, Hewlet-Packard, and IBM.

At the same time, Digital and Cadence Design Systems announced the PowerFrame framework program and began in all-out race to be the first to provide multiplatform, multivendor support across the entire engineering process. Cadence's own tool framework is supported by PowerFrame, as is Valid's. In addition, Teradyne Inc., of Boston, will support PowerFrame with its framework, and a host of other suppliers have already had their tools encapsulated under the Digital System. Digital is already working with customers to encapsulate their existing tools for use in the design management framework. Both Cadence and Digital say that the framework will conform to the standards that are set up by CFI.

Digital is also working with Objectivity Inc., Menlo Park, Calif., to support an object-oriented database for PowerFrame. Unlike traditional hierarchical or relational databases, object-oriented databases (ODBMSs) make it possible to provide consistent control of the tools and data used in by a design group, while still allowing the group to share design data with others in an organization. One can expect that ODBMSs will underly all frameworks in the future.

Mentor Graphics was also vying for the open framework prize with Falcon Framework 8.0, which will be supported by the many vendors who have joined Mentor's Open Door Program. Among them are Analogy, EEsof, Meta-Software, Seattle Silicon, Synopsis, TSSI, and Vantage Analysis Systems. Mentor shares with the Open Door Program members the details of its Engineering Design Data Format, so that all their tools can exchange data in a closely coupled fashion on the HP/Apollo and Sun platforms that Mentor is pledged to support. However, a month before the framework's scheduled shipping data of November, Mentor announced that it will slip to the first quarter of 1991, giving its competition more of a lead in the race. Further, the company's port of its EDA/framework products to Sun workstations has also slipped to the second quarter of 1991. Digital and Cadence frameworks are already working in multiplatform environments.

The race by these companies to make a particular framework an open standard parallels the operating system battle. By controlling a standard, a group can steer the industry in the direction that most benefits it. However, the fact that those pushing frameworks already have a large installed base make it likely that there will be multiple de facto standards.

Users, though, are behind the push for a standard framework, because they need to use multiple software tools that work together to complete a project. Frameworks, coupled with other standards such as EDIF and VHDL, promise a unified environment with a consistent interface to the tools, a unified way of exchanging data, and a means of controlling tool configurations and data versions used for a project—in effect enabling engineers in all areas of product development, procurement, manufacturing, and support to work as a unified team. Providing this capability, referred to as concurrent engineering, will be the goal of CAE companies in 1991.

PC EDA

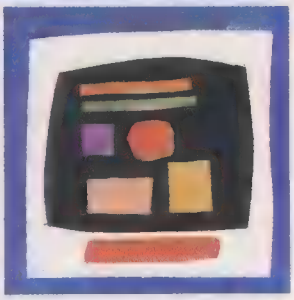
The role of the PC as an EDA platform has not been clearly indicated by any of those involved in the framework programs. However, it is clear that there are a number of engineers who believe that desktop engineering will be the province of the PC and the Macintosh. The number of programs that are available for these two environments grew substantially in the past year, and analog and digital signal-processing designers now have a wealth of tools from which to choose ["Special guide to software," *IEEE Spectrum,* November 1990, p. 47].

To ensure their future, tool vendors are taking care to see that their products will work in multiple environments. For example, PSpice, by MicroSim Corp., Irvine, Calif., runs on all the major EDA platforms and appears the same to a user regardless of the environment in which it is running. This has made PSpice a de facto standard for analog simulation, although vendors such as Intusoft, San Pedro, Calif., are getting a lot of attention from analog designers who want more tool freedom. (Intusoft's products are highly modular, so that they can work with other tools the designer might prefer.)

Another important development in CAE tools last year was the emergence of electromagnetic simulators as mainstream tools. Whereas EM simulators once required that the user be a specialist in finite-element analysis and other esoterica, a new group of tools such as EM-Sim from EEsof Inc., Westlake, Calif., and Maxwell 3D from Ansoft Corp., Pittsburgh, now enable the average digital design engineer to undertake the analysis of such phenomena as crosstalk and microwave effects with ease.

Spectrum staff—Software

MINIS AND MAINFRAMES



The mainframe resurges
NEC delivers high-end machine
AT&T courts NCR, open systems
European firms merge

Several years ago, some computer analysts wondered how long the conventional mainframe computer, the industry's backbone ever since its birth, could survive. At the time, superminicomputers were becoming more powerful in leaps and bounds, a new class of small supercomputers, or minisupercomputers, was just starting to take hold, and the first commercial machines based on various forms of parallel processing had just hit the market.

Was it possible that such a vast category as the mainframe, pressured on every front, could be simply squeezed out of existence?

Of course not, was the apparent answer of IBM, Fujitsu, Hitachi Data Systems, and Amdahl, which led the mainframe's resurgence with product introductions last summer. Earlier, important new mainframes had emerged from Digital Equipment and Tandem Computers and were delivered to their first buyers last year. All told, the mainframe's status as the machine of choice for large numbers of users running mathematically unexceptional applications—in business, for example—was solidified.

On Sept. 5, in what it called its "most comprehensive" product announcement in over 25 years, IBM Corp. proclaimed a line of 18 computers, three operating systems, new technology for connecting computers and peripherals over a large area, and related improvements and technical advances.

IBM also enhanced its standard mainframe architecture, the Enterprise Systems Architecture/370 (ESA/370), with the ESA/390. In the ESA/370, introduced in February 1988, improved virtual memory relieved programmers of the need to explicitly track the movement of data and program code in secondary storage. Also, addressing was effectively boosted to 31 bits, creating a vast virtual memory space. In the ESA/390, these improvements have been extended to the entry- and middle-range computers.

The new line of computers, called the Enterprise System/9000, comprise eight water-cooled, six air-cooled, and four rack-mounted offerings, which supplant existing mainframe and midrange lines. The water-cooled models replace IBM's 3090 mainframe line; the top-of-the-line ES/9000 Model 900 has roughly twice the processing power of the 3090 Model 600J, previously IBM's top mainframe. The air-cooled models replace the ES/4381 line of midrange computers; the top one, the ES/9000 Model 480, offers over four times the performance of its predecessor, the ES/4381 Model 92E. In addition, vector processors will be available for the new air-cooled units, the first IBM has offered for a midrange computer line. The rack-mounted models take over from the ES/9370 line of low-midrange machines.

The ES/9000 computers are built around one to four or six processors. In the top-end models, higher performance was achieved chiefly through improvements in packaging and logic technologies already used in the 3090 mainframes. In both the 3090s and the new ES/9000s, IBM grouped processor and memory chips into what it calls "thermal conduction modules." In this technique, which is common in large computers, ICs are grouped on specially designed substrates, rather than being individually packaged and installed on printed-circuit boards.

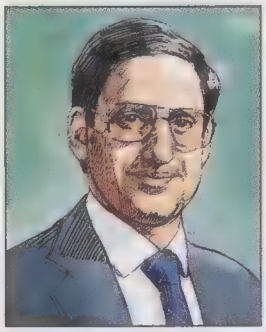
But in the top ES/9000s, IBM has improved matters by using a ceramic substrate of alpha cordierite, the better to conduct heat away from the wiring and ICs—which therefore can be spaced closer together. Thus four of these modules now hold as many ICs as six did in the 3090 mainframes, the company said. The circuits themselves employ emitter-coupled logic (ECL) with 1-micrometer features. Having twice the density of previous chips, they achieve picosecond speeds.

One of the three operating systems introduced for the ES/9000s allows clustering of mainframes to work on a single application, not unlike the "VAXcluster" capability already offered by Digital Equipment Corp. Nicknamed "sysplex" by the company, it owes its existence to new systems that synchronize the clocks of different mainframes and so allow programs to communicate and exchange status information.

Also introduced was an optical-fiber–based connection architecture that enables users to connect a mainframe to peripheral devices, such as mass-storage units and printers, up to 9 kilometers away. This capability is considered important in campus settings and in urban, downtown areas where high real-estate prices make it preferable to install computer equipment off-site. "It is a significant advantage, and the distances will continue to increase," said Stephen Josselyn, a senior analyst with International Data Corp. in Framingham, Mass. The copper-cable links of the

Glenn Zorpette Associate Editor

COMPUTER INDUSTRY AT A TROUBLESOME JUNCTURE



BRAD M. FRIEDLANDER: EXPERT OPINION

'Maintenance of heterogeneous environments represents a trend toward recognizing and treating service as an important profit center.'

The computer industry has reached a potentially troublesome juncture: with vendors finding that survival depends increasingly on excellence in areas unrelated to the major concerns of users, 1991 will find the two groups somewhat at odds.

While there may be some improvement in the near future, the major developments that users need will probably have to wait at least until 1992. Thus the chasm between vendors' and users' needs will lead to short-term problems and, consequently, opportunities for niche players.

The past 12 months have seen evolutionary advances in technology rather than breathtaking leaps. Recent progress has centered on improved price/performance ratios and on balancing input/output bandwidth with central processing unit performance. Meanwhile, the important area of "environmental" software—loosely defined as all software that enables applications or application packages—has lagged, and may have even lost more ground to hardware during 1990.

To list some of the more notable developments:

- The emergence of commercial-grade versions of Unix that, while still lacking the capabilities of many traditional operating systems, are being used to support mission-critical commercial

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past were limited to distances of only a hundred or so meters.

New mainframes

Several months before the news from IBM, Hitachi Data Systems, Santa Clara, Calif., added three high-end models to its HDS EX series of mainframes, which are based on IBM's ESA/370 architecture. The top two of these—the three-processor EX 310 and four-processor EX 420—feature ECL circuitry with 12 000 gates per array and switching speeds in the 70-ps range. The chips are grouped in so-named high-density modules, not unlike IBM's thermal conduction modules. Hitachi also gave notice that it intended to produce a 370-compatible vector processor for the 310 and 420. The third machine introduced, the EX 85, is a three-processor economy model; it lacks many of the other two's semiconductor and packaging advances.

The day before IBM's 390 proclamation, Tokyo's Fujitsu Ltd. took the wraps off the M-1800 line of five mainframes. The fastest is the eight-processor M-1800/ 85, which Fujitsu called "the highest-performance general-purpose computer in the world." Although no absolute performance figures were given and such claims are made all the time, the machine seems destined to influence the market, analysts said. "It's the first eight-way processor in a mainframe," said Josselyn. "We'll probably see an eight-way processor from IBM and Hitachi at some point."

Fujitsu also supplemented its VP2000 line of supercomputers with the VP2400/40 and the VP/2200/40. Each has four scalar and two vector processors. Claimed peak rates are 5 and 2 billion (10^9) floating-point operations per second, respectively.

Two weeks after the IBM announcement, on Sept. 18, Amdahl Corp., Sunnyvale, Calif., countered with its new 5995 processor series of 10 model numbers. The A series essentially repackages the current 5990 series, but the M series adds significant new capabilities. The high-end units, for example, are six- and eight-way multiprocessors. The 5995 series was developed independently of Fujitsu, although it was based on IC and memory technologies supplied by the Japanese company.

Most of the new machines, from all manufacturers, are scheduled for delivery later this year.

Last year was also a big one for fault-tolerant computers, a category of large machines that use redundant elements to guarantee exceptional reliability for applications in finance, the airline industry, and the like. New fault-tolerant offerings came from most of the major mainframe vendors, and Unix-based fault-tolerant computers also emerged.

Fujitsu's line, the Sure System 2000, made its bow on Sept. 11; Tokyo's NEC Corp. announced it would resell machines from the second largest maker of this kind of system, Stratus Computer Inc., of Marlborough, Mass.; Hewlett-Packard Co., Palo Alto, Calif., revealed it would resell machines by Sequoia Systems Inc., also in Marlborough; and at press time, analysts were expecting Hitachi to unveil ■ fault-tolerant computer by the end of 1990.

Last January, the leader in this field, Tandem Computers Inc. of Cupertino, Calif., introduced ■ fault-tolerant reduced-instruction-set computer (RISC) with a Unix operating system. Even Digital Equipment Corp. came out with the VAXft 3000 Model 310, which the Maynard, Mass., company said would be the first of ■ series of fault-tolerant VAXes.

Supercomputers advance

If NEC's claims hold up to international scrutiny, 1990 was quite a year for the Tokyo-based company. In June, it delivered its first SX-3 supercomputer, promised in the spring of 1989 ["Jap-

HIGHLIGHTS

Success: IBM Corp. unveiled Enterprise Systems Architecture/390, its new mainframe architecture.
Shortfall: Data General Corp. and other makers of traditional, proprietary minicomputers went on struggling to adapt to a market moving to open systems.
Notable: Digital Equipment Corp., the second largest computer company, announced it would make its VMS operating system compatible with a version of Unix.
Newsmaker: AT&T chairman Robert E. Allen, who launched a hostile bid for NCR Corp.

applications. However, the proliferation of proprietary Unix versions looms as a future stumbling block.

- IBM Corp.'s introduction of the System/390, important mainly because of the vast number of users of the company's MVS (Multiple Virtual Storage) computers. The S/390 products allow IBM to provide the same environmental software for large systems on down to small departmental processors. Although other vendors, including Digital Equipment Corp., have long had this capability, it has eluded MVS users. It remains to be seen how well the large-system environmental software (such as DB2) performs on the smaller processors.
- Possibly the most important development of all, IBM's greater willingness to service products other than its own. This is not entirely new with IBM or other firms (Digital's Customer Service Business unit is another example), but last year IBM expanded its activity in this area to include data processing and facilities management, mainframe utility (via IBM's Information Network, IIN), and systems integration. As mainframe sales hold steady or decline, maintenance of heterogeneous environments represents a trend toward recognizing and treating service as an important profit center.

Behind the emphasis on service is another critical issue: product differentiation in the face of the ongoing migration toward more standardized, open systems. By their very nature, open systems limit differences, forcing vendors to set themselves apart by focusing on the few allowable distinctions: service is one, and the choice of a reduced or ■ complex instruction set is another.

Meanwhile, the market for minicomputers and mainframes is being shrunk by the economic slump and by low-end infringement. The latter stems from the ability of workstations to offload servers through effective use of distributed and cooperative processing. For vendors, the problems of a decreasing market are compounded by:

- Decreasing profit margins in hardware, particularly in the more commoditylike market segments such as open systems.
- Increasing competition from niche players, because it is relatively easy for a competent engineer to design ■ computer based on off-the-shelf parts and send it to the Pacific Rim for economical production.
- Continued shortening of product life cycles—it is already possible for delays from chip makers to kill ■ product introduction.

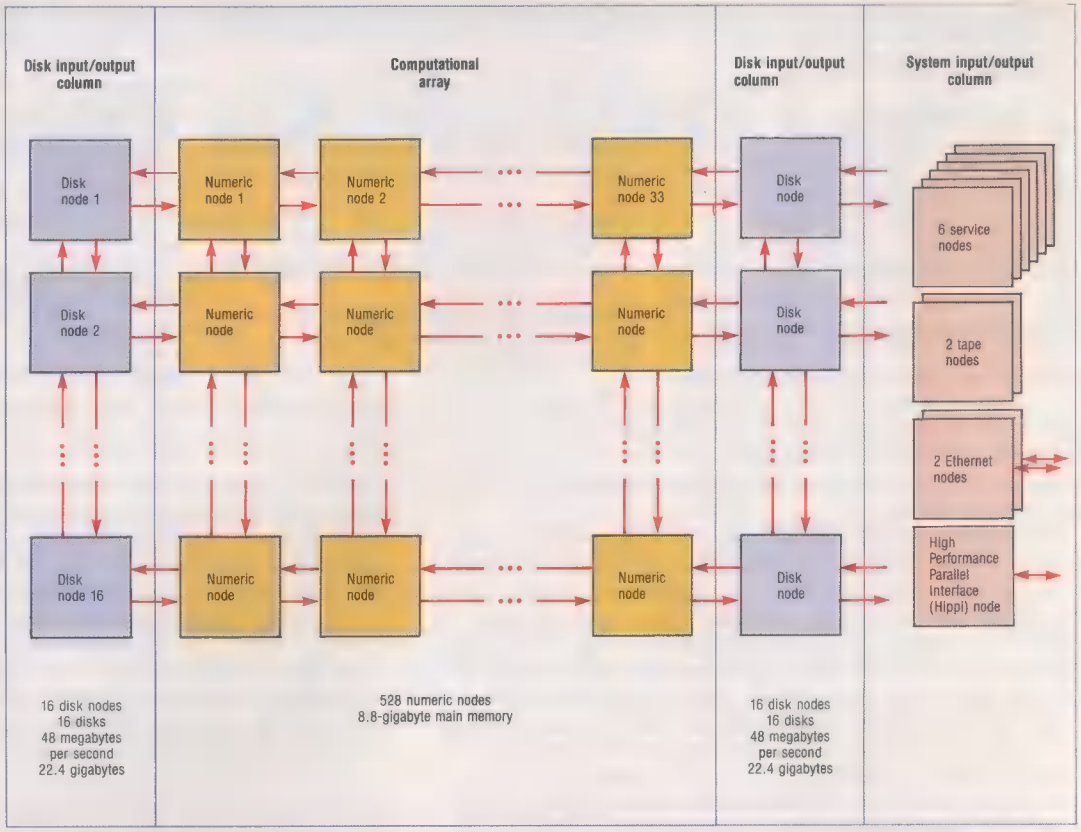
Computer users, meanwhile, face a different set of issues. They are concerned with the time needed to respond to changes in business plans, and with the costs of operating and maintaining computer systems. They want to integrate and manage heterogeneous networks of platforms as ■ single system. They want reliability and high availability.

Increasingly, they also want open systems, but they are finding that open systems are not really open. The "holy grail" of vendor independence cannot be achieved today, though some users are finding they can, at least, avoid hardware dependence. This is leading lifelong customers of one vendor to consider changing to another.

A lack of software that makes highly effective use of massively parallel architectures is ■ particular problem for computer users in scientific fields. As some have already realized, the cost of rewriting applications for the newer hardware can far outweigh the potential savings from the better price/performance of the newer hardware. This is ■ subset of the old application-development issue that has always hindered new architectures.

—Brad M. Friedlander

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The Touchstone Delta System, a massively parallel machine being built by an Intel division for a group of 14 U.S. research organizations, will incorporate 528 of Intel's i860 microprocessors, arranged in a two-dimensional mesh interconnection (two separate groups of "disk nodes," based on 80386 microprocessors, will be dedicated to I/O chores). The computer will have a theoretical peak processing rate of about 32 billion floating-point operations a second, Intel said.

anese boost speed of supercomputers," THE INSTITUTE, November 1990, p. 1]. For the top SX-3 machine, the US $24 million Model 44, NEC claims a peak processing rate of 22 gigaflops, which would make it by far the world's fastest computer. Analysts, however, gripe that such peak rates are never achieved with actual programs. By way of comparison, the next generation of machines from the two remaining U.S. supercomputer makers, Cray Research Inc. in Eagan, Minn., and Cray Computer Corp. in Colorado Springs, Colo., are expected to be 16-gigaflops machines, and will not be delivered for possibly a year or more.

Cray Research, the leader in supercomputers, with nearly two-thirds of the world market, concentrated on improving the middle and low-end of its product line. In May, it unveiled the Y-MP2E, a lower-cost, lower-performance alternative to the Y-MP8 line of supercomputers. The machines sell for between $2.2 million and $5.8 million, depending on configuration (as opposed to as much as $25 million for the top Y-MP8). The Y-MP2Es are available with one or two processors and up to 64 million 64-bit words of memory.

Cray alleged the machines attained 20–50 megaflops on the so-called Perfect benchmarks, which, unlike peak performance figures, are held to represent actual performance. However, this allegation conflicts with a report last March from the Center for Supercomputing Research and Development at the University of Illinois in Urbana, which credits the much more powerful, eight-processor Cray Y-MP/832 with an overall harmonic mean of 22.2 megaflops on the full set of Perfect benchmarks.

Last March, Cray disclosed its plans to buy SuperTek Computers Inc., a Santa Clara, Calif.-based maker of Cray-compatible minisupercomputers. Early October saw the first fruit of that acquisition, the XMS system. Coupled with the Y-MP2E introduction, the moves pit Cray Research squarely against Convex Computer Corp., Richardson, Texas. Convex is the leading maker of minisupers, which offer a significant fraction of supercomputer performance at often a smaller fraction of the cost.

Cray's XMS machine is based on the S-1 computer developed by SuperTek and runs Cray's Unicos operating system, a derivative of Unix System V. Another minisupercomputer, compatible with the Y-MP line, is expected before the end of 1991, Cray said.

Notable developments in Cray Research's managerial suite included the departure of president Marcelo A. Gumucio, who is said to have fallen out with Cray chairman John A. Rollwagen. Also, a team was formed at the company to develop massively parallel architectures; analysts said the move was significant and may herald additions to Cray's line in coming years.

The rush to open systems

In the superminicomputer arena, trends incipient in 1989 became facts of life in 1990. These were the downturn in this market segment, and the industry's response: a migration away from proprietary systems toward more standard (or "open") architectures and operating systems—RISC and Intel microprocessors, on the one hand, and Unix and MS DOS, on the other.

Digital, the father of the superminicomputer, exemplified both trends. Stuck with many of its competitors in a two-year earnings slump, Digital said last fall that it planned to lay off 8000 of its 124 000 employees by the end of the year and to continue a voluntary retirement program in hopes of trimming another 5000 workers in 1991.

The company has resisted pressures to alter the proprietary VMS (virtual memory system) operating system run by its minis and superminis, so that it could run software written for the so-called open operating systems, such as Unix and its many derivatives. But in a series of moves last fall, Digital moved aggressively into open systems.

On Oct. 16, the company introduced the applicationDEC 433MP line of multiuser computers based on one to six Intel 80486 microprocessors, which are standard in top-of-the-line MS DOS personal computers. Priced at $17 500 to $100 000, the line executes 20 million to 100 million instructions per second (MIPS) and runs a version of Unix that can accommodate applications written under the MS DOS, Pick, or Mumps operating systems, Digital said. Scarcely a week later came the disclosure that the venerable VMS would be altered to run programs written for a version of Unix. The company also revealed long-term plans to

incorporate RISC technology into its VAX superminicomputers, whose vast instruction set is considered by some the very antithesis of RISC. (At present, Digital uses RISC processors only in ■ line of workstations.)

Overshadowed by the applicationDEC, RISC, and Unix announcements was other news about additions to Digital's standard VAX line of superminicomputers. The VAX 4000 Model 300, introduced in July, is a network server, ■ machine designed to anchor ■ network of single-user computers to shared applications, databases, or communications facilities. Another new VAX, the 6500, was added to the VAX 6000 mid-range line in October.

But probably the fiercest thrust into open systems last year was made by NCR Corp. The Dayton, Ohio–based firm trumpeted a family of general-purpose computers based on Intel microprocessors, such as the 80486. System 3000, as the line is called, will eventually encompass dozens of models on seven levels, spanning ■ performance range from 7.5 MIPS to 100 000 MIPS, NCR said. It is believed to be the first family of computers based on microprocessors to have such ■ wide performance range. The lower-performance System 3000 models use MS DOS operating systems and the higher ones, ■ version of Unix.

Computer analysts were generally pleased with NCR's strategy, but AT&T Co., which has long sought ■ position of prominence in the computer industry, was downright enthusiastic: it launched a hostile takeover bid for NCR on Dec. 3. AT&T said NCR's strategy of emphasizing open computing would mesh perfectly with its own—its people, after all, created Unix in 1969. But NCR chairman Charles Exley spurned the offer, saying he did not want to be burdened with AT&T's computer division, which he termed ■ "real mess."

The System 3000's top line of machines, designated 3700, will be configurable with thousands of microprocessors, the company said, but did not indicate when they would be available. Only six models were introduced in September, four of them being single-processor machines—three desktop machines in the 3300 level, and one in the 3400 level. Another 3400-level offering is configurable with one to four 80486s. Also introduced was one 3500-level machine, built around two to eight 80486 microprocessors, and put by the company in the "mainframe class."

In January of last year, Hewlett-Packard Co. wheeled out 24 computers based on Precision Architecture, the company's RISC implementation. The newcomers added five models to the HP 9000 line, intended originally for technical users, and eight to the 3000 line, mainly for applications in business or transaction processing. The other 11 were network servers.

Data General Corp., Westborough, Mass., is fast becoming a business-school case of what happened in the early 1990s to minicomputer manufacturers that were slow to adopt open systems. It reportedly spent heavily on R&D for ■ new line of computers based on open processors and software. Over in Lowell, Mass., the news was a little more encouraging at Wang Laboratories Inc., another company suffering because it hesitated to embrace open systems. In the first fiscal quarter of 1991, Wang turned a profit, something it had not done in seven quarters.

Big acquisitions in Europe

The trend among European computer makers was consolidation. In Germany, Siemens AG of Munich bought Nixdorf Computer AG of Paderborn. The result is Siemens Nixdorf Informationssysteme AG, the eighth largest computer company in the world and the largest one headquartered in Europe. It controls the second largest share of the European market. Shortly before the Nixdorf acquisition took effect, Fujitsu Ltd. announced its intention to purchase a majority stake in London's International Computers Ltd. (ICL), Britain's only large-computer manufacturer.

Some European computer analysts predicted that the ultimate winner of the four companies in the two deals would be Fujitsu. With ICL, the Tokyo-based giant gains an entree into the European computer market (albeit a small one: ICL supplied only 1.8 percent of that market in 1989, according to Dataquest Inc., the San Jose, Calif., market research firm). Even the Siemens-Nixdorf marriage benefits Fujitsu, which supplies the merged German firm with supercomputer technology for resale. Thus Fujitsu may become a power in the European computer industry.

Cray's disclosure in early October that it would investigate commercial massively parallel computers was only one of several gains logged by the architecture in 1990. Tens of millions of dollars in venture capital were raised last year by the handful of U.S. firms—mostly small, private ones—offering massively parallel computers, even though nearly all of them have sold under a few dozen machines.

One of the older companies in the field is Beaverton, Ore.–based Intel Supercomputer Systems Division, part of the semiconductor company, which introduced its first iPSC machines in 1985 ["Minis and mainframes," *Spectrum*, January 1986, p. 36]. The iPSC has ■ hypercube architecture, in which connections between individual processors (nodes) become more numerous as the machine is expanded with new nodes. The previous generation iPSC/2 could have anywhere from eight to 128 nodes, all based on the company's own 80386 microprocessors. Last year, Intel brought out a new version of the machine, the iPSC/860, in which the 80386s are replaced with the much more powerful i860 microprocessors. Depending on the number of nodes, the iPSC/860 offers 480 megaflops to 7.6 gigaflops, which compares favorably with what the highest-performance conventional supercomputers can do.

With costs far below those of conventional supercomputers, the main obstacles to more widespread use of massively parallel systems are lack of software and lack of resources to educate potential users, according to ■ recent study by the New York City market research firm Frost & Sullivan Inc. Most of the machines have been sold for special-purpose, noncommercial applications in academic, Federal, or military research.

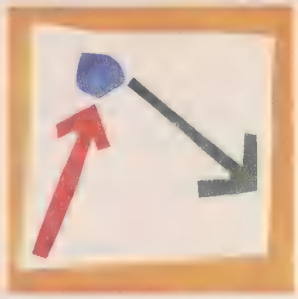
The best recent example is the Touchstone Delta System, a massively parallel machine being built by Intel for a group of 14 mostly Federal U.S. research organizations led by the California Institute of Technology in Pasadena. The machine will incorporate 528 of Intel's i860 microprocessors [see diagram, p. 42] and have a theoretical peak processing rate of about 32 gigaflops. Intel won the contract in mid-November, and the system—to be applied to military work and so-called scientific "grand challenges," including studies of global warming, visualization, and chemical reactions—is to be completed by next spring.

Intel also reported sales last year of the iPSC/860 to Boeing, Ford Motor, and Prudential-Bache Securities. Overall, Intel says, 22 percent of the 200 iPSCs sold so far have been to industry.

The massively parallel architecture also returned to its roots last year. One of the first such machines, the cosmic cube at Jet Propulsion Laboratory in Pasadena, was designed in the early 1980s for calculations associated with high-energy physics. Last year, physicists were putting the finishing touches on, or operating, more powerful massively parallel machines for similar research at Columbia University in New York City, IBM's Thomas J. Watson Research Center in Yorktown Heights, N.Y., the Fermi National Accelerator Laboratory in Batavia, Ill., the University of Tsukuba in Japan, and the University of Rome in Italy.

Massively parallel technology is advancing so rapidly that plans to build the first machines capable of executing one trillion (10^{12}) instructions per second, or 1 teraflops, have already been made. Recently, Thinking Machines Corp., of Cambridge, Mass., began working on a design for such a machine under a $12 million grant from the Defense Advanced Research Projects Agency, Arlington, Va. And last January, physicists meeting in Tallahassee, Fla., agreed to draw up ■ detailed proposal for ■ 1-Tflops machine; the proposal was to be submitted to the U.S. Department of Energy's high-energy physics division. "There's a large number of obstacles between here and there [building the machine], but we have ■ small group of very dedicated people," said physics professor Norman Christ of Columbia University. ◆

TELECOMMUNICATIONS



Deregulation sweeps the world
Broadband network standard is set
All-optical transmission becomes reality
Mobile communications untethers the user

The bell that tolled the breakup of AT&T Co. back in 1984 in the United States has been ringing in the demise of many other national telephone monopolies. Last year half a dozen countries deregulated their telephone companies to admit competition in the hopes of accelerating technological development. One of the leading technologies to take off was mobile communications, particularly services based on digital transmission.

Last year a worldwide standard for the broadband integrated-services digital network (ISDN) was finally accepted, enabling worldwide compatibility for the emerging fiber-optics-based broadband ISDN systems. Meanwhile, narrowband ISDN crossed international borders for the first time, offering transoceanic service.

In optical-fiber transmission, the most promising development was erbium-doped optical amplifiers, which are cheaper and simpler for long-distance communications, especially if many signals are to be multiplexed onto one fiber. In addition, investigators demonstrated a simple processor entirely based on optical logic elements and parallel optical connections through free space, which may be another significant step toward an optical computer.

International push for deregulation

In November the British Government announced that it would deregulate much of the nation's telecommunications industry, including erasing most of the legal restrictions separating the telephone and cable television industries. Access to the local, long-distance, and international service markets—until now the domain of only British Telecommunications PLC (British Telecom) and Cable & Wireless PLC's subsidiary Mercury Communications Ltd., both headquartered in London—would be largely unrestricted. British cable television companies would be allowed to offer local telephone service, and British Telecom and Mercury would be allowed to offer cable television and other entertainment over their phone lines by the end of the decade. The overall plan is expected to take effect this year, perhaps with some modifications, after comments are received by the Government on Jan. 14.

Meanwhile, in the United States, the Bell regional holding companies—the seven companies formed by the AT&T divestiture to handle local service—have continued their push to free themselves from the three major restrictions of the Modification of Final Judgement (MFJ), the court settlement that outlined the terms of the divestiture.

The MFJ forbids the regionals from manufacturing and from offering information and interexchange long-distance services. Last year more than a dozen bills aimed at removing the restrictions were introduced into the House of Representatives and the Senate. The companies also want the U.S.'s regulatory agency, the Federal Communications Commission in Washington, D.C., to oversee them, and not Federal District Judge Harold H. Greene, the judge who approved the MFJ in 1982 and who has retained jurisdiction ever since.

The Bell regionals claim that the MFJ's restrictions keep them from being fully competitive both in the United States and abroad. Opponents claim, however, that those constraints protect consumers from the same kind of alleged abuses that caused the U.S. Government to bring suit against the Bell System in the first place.

As evidence, some have pointed to the FCC's audit last year of Nynex Corp., New York City, whose purchasing unit was stated to have systematically overcharged New York Telephone, New York City, and New England Telephone & Telegraph Co., Boston, Mass., between 1984 and 1988 for equipment, supplies, and services, leading the two to pass some of those costs along to their interstate customers. The FCC agreed to end its investigation "without any finding of wrongdoing, violations, or liability" once Nynex agreed to pay a fine and refund the interstate customers by reducing their rate base.

Deregulation sweeps through Europe

While complete deregulation was thus thwarted for another year in the United States, it has swept through other countries at record pace. Effective this month, France Télécom is removed from the control of the Paris-based Posts & Telecommunications Ministry. The change—achieved by splitting the telephone and postal services into independent organizations—will allow France Télécom to manage its own budget and disbursements free from periodic raids by other government programs. It is not a full-scale privatization because the French Government's aim was to help the telecommunications authority become more internationally competitive while preserving its public service role. In line with the European Community's telecommunications services direc-

Trudy E. Bell Senior Editor

MOBILE COMMUNICATIONS PROMISE PERSONAL FREEDOM



LAURENCE B. MILSTEIN: EXPERT OPINION

'Communications freed from the tether of today's wired or cellular systems will yield an unprecedented level of flexibility.'

During the past year the hottest telecommunications area has almost assuredly been mobile communications—especially in relation to digital cellular telephones and the new personal communication networks.

The digital cellular focus has been on defining and designing a second generation of car phones for the 900-megahertz band, to increase capacity and reduce interference. The current generation of car phones—analog FM radios with each channel occupying 30 kilohertz of bandwidth—suffers from congestion in major cities. Transferring to a digital system will at least triple capacity while creating cleaner channels with greater security and privacy.

As yet unclear is which channel-accessing technique will become standard. One contender is time-division multiple access

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tive, France Télécom would keep its monopoly on the basic network and voice telephone services, but will lose it on data communications, terminal equipment, and value-added services, which will be open to competition.

Across the Rhine, the Deutsche Bundespost, Bonn, also decided to suspend its monopoly on the basic telephone service in order to help overcome the shortage and poor quality of telecommunications links between the former East and West Germanys. Post Minister Christian Schwarz-Schilling said companies might now use satellite links to transmit voice and data to East German subsidiaries and they might offer this service to third parties. The controversial suspension, which may be challenged in court by the postal trade union, is to last only three or four years. But supporters of further deregulation of telecommunications in Germany hope it is the first step toward private sector competition in the telephone system.

In 1989, the German Bundespost had completely deregulated data transmission and made it easier for private companies to lease lines. But private competition was not allowed on the basic voice service.

In March, the Japanese Government's Telecommunications Council recommended that Nippon Telegraph & Telephone Co., Tokyo, Japan's telecommunications giant, should be split into three companies within five years. The two-year study contended that NTT's virtual monopoly of telephone service has hindered competition in Japan's telecommunications market and fostered inefficient management.

The council said that NTT—the world's biggest company in terms of stock market value—should be divided into local, long-distance, and mobile telecommunications service firms. The Japanese cabinet, however, voted to table any action until 1995. NTT was turned into a private corporation in 1985 ["Japan telecommunications at the crossroads," by Tadao Saito, *IEEE Spectrum*, November 1990, pp. 126–28 and "From monopoly to competition, long-term research is vulnerable," *Spectrum*, October 1990, pp. 46–50].

In Australia, Prime Minister Bob Hawke announced that the telecommunications market there is to be opened to unlimited competition by 1997. That move could cut domestic telephone charges by 40 percent. The cabinet in neighboring New Zealand voted to privatize the state-owned New Zealand Telecom Ltd., Auckland, as well.

HIGHLIGHTS

Success: Erbium-doped optical-fiber amplifiers were developed.
Shortfall: Economical components for coherent optical communications have not yet been developed.
Notable: Mobile communications continued to develop.
Newsmaker: Many countries' telecommunications organizations were deregulated.

Meanwhile, the debt crisis in Latin America has forced Argentina, Chile, and Mexico to offer stakes in their telephone monopolies to foreigners. In December, the Mexican government sold control of its national telephone company, Teléfonos de México (Telmex), to a consortium made up of Grupo Carso of Mexico, Southwestern Bell Corp., and France Télécom. The sale, at US $1.76 billion, was the largest cash purchase ever to be made in a privatization program in a developing country.

And the revolutions in eastern Europe and elsewhere have attracted private telecommunications companies from all over the world into Bulgaria, Czechoslovakia, the former East Germany, Hungary, Poland, Romania, and Mongolia. The Soviet Union is also gearing up to modernize its telecommunications networks, although so far the Soviet Government has not favored demonopolization.

Broadband network standard set

Last year the International Telecommunication Union's International Telegraph and Telephone Consultative Committee (CCITT), based in Geneva, adopted the asynchronous transfer mode (ATM) standard for broadband ISDN services. This standard should ensure worldwide compatibility among the optical-fiber broadband ISDN systems now emerging and has already led to the scheduling of trials in Europe, Japan, and the United States, for 1992 and 1993. Commercial products for these trials are believed to be under development by most major manufacturers worldwide.

The ATM standard defined the packet (or cell) speed, size, and format for all broadband switches. First to announce a commercial broadband ISDN switch was Fujitsu Ltd., Tokyo, which demonstrated a prototype ATM switch at Supercomm/ICC'90, the International Conference on Communications held in Atlanta, Ga., last April. Constructed with BiCMOS RAM and logic gate arrays and switching 512 by 512 lines with 150 megabits per second, it is the largest switch so far announced. Others are expected this year.

(TDMA), in which n users share a single carrier by being assigned all the nth time slots for their information. The other is code-division multiple access (CDMA), where each signal consists of a different binary sequence that modulates the carrier, spreading the spectrum of the waveform; the signals are separated in the receiver by using a 'correlator' that accepts signal energy only from the selected binary sequence.

Currently there are strong proponents of each technique. If the industry is unable to conform to a uniform standard, some regions of the country might use TDMA while others use CDMA, depending on which cellular company serves the particular geographical area.

Closely related to the digital cellular work is that of the personal communication networks (PCN). Unlike the digital cellular systems, the PCNs are designed to operate independently, as well as interface with the standard wired telephone network. Although PCNs will themselves be digital, they will differ from digital cellular systems for car phones and other mobile communications in several key respects.

The PCNs will operate in the 1.9-gigahertz region. The radios are intended to be both small and light enough to fit comfortably in a shirt pocket. Because their transmission power will be low, many more base stations will be required than for digital cellular systems—and thus PCNs are sometimes dubbed microcellular systems.

Perhaps the most important distinction between the two, however, is less a function of technology than of concept: with the PCNs, a user will have a personal identification number, eliminating the need for separate phone numbers for home, office, or anywhere else.

Technically, the same issues debated in the digital cellular industry are under study for PCNs. Some major companies, such as Motorola Inc., Schaumburg, Ill., are designing a TDMA-based network while others, such as Millicom Inc.'s subsidiary PCN America Inc., and SCS Mobilecom Inc., are experimenting with systems using CDMA and various other digital spread-spectrum techniques.

One of the more interesting tests, devised by PCN America, overlays a spread-spectrum PCN on an existing network of narrowband users (primarily utility companies) at the same frequencies, to determine if the two sets of users can coexist without excessive interference.

Whatever the outcome of the specific technical considerations, communications freed from the tether of today's wired or cellular systems will yield an unprecedented level of flexibility and perhaps whole new industries.

Laurence B. Milstein (F) is professor of electrical and computer engineering at the University of California in San Diego, with particular interest in spread-spectrum technology. He is also the IEEE Communications Society vice president for technical activities, and is a member of the board of governors of the Information Theory Society.

Meanwhile, last year, for the first time, narrowband (64-kilobit-per-second) ISDN went international. As early as 1988, after years of anticipation, isolated local areas in Japan, Europe, and the United States began offering these services commercially. In January, AT&T announced that customers in 37 U.S. cities could dial a 64-kb/s channel to Japan and the United Kingdom. In April, international 64-kb/s ISDN was launched between Kokusai Denshin Denwa (KDD), based in Tokyo, and France Télécom's Numeris data network, with the first two customers beginning to use it for data and Group 4 (high-resolution) facsimile transmission.

All-optical transmission becomes reality

Last year the erbium-doped fiber amplifier emerged as the undisputed champion of lightwave communications technology. It surpassed even the optimistic predictions of the year before for low noise (close to the quantum limit of 3 decibels), low coupling loss (less than 0.5 dB), high saturation power (up to tens of milliwatts), polarization independence, and virtually complete freedom from nonlinear distortion over thousands of kilometers. Many experts believe that erbium-doped fiber amplifiers will revolutionize long-distance optical communications, from video distribution to broadband networking.

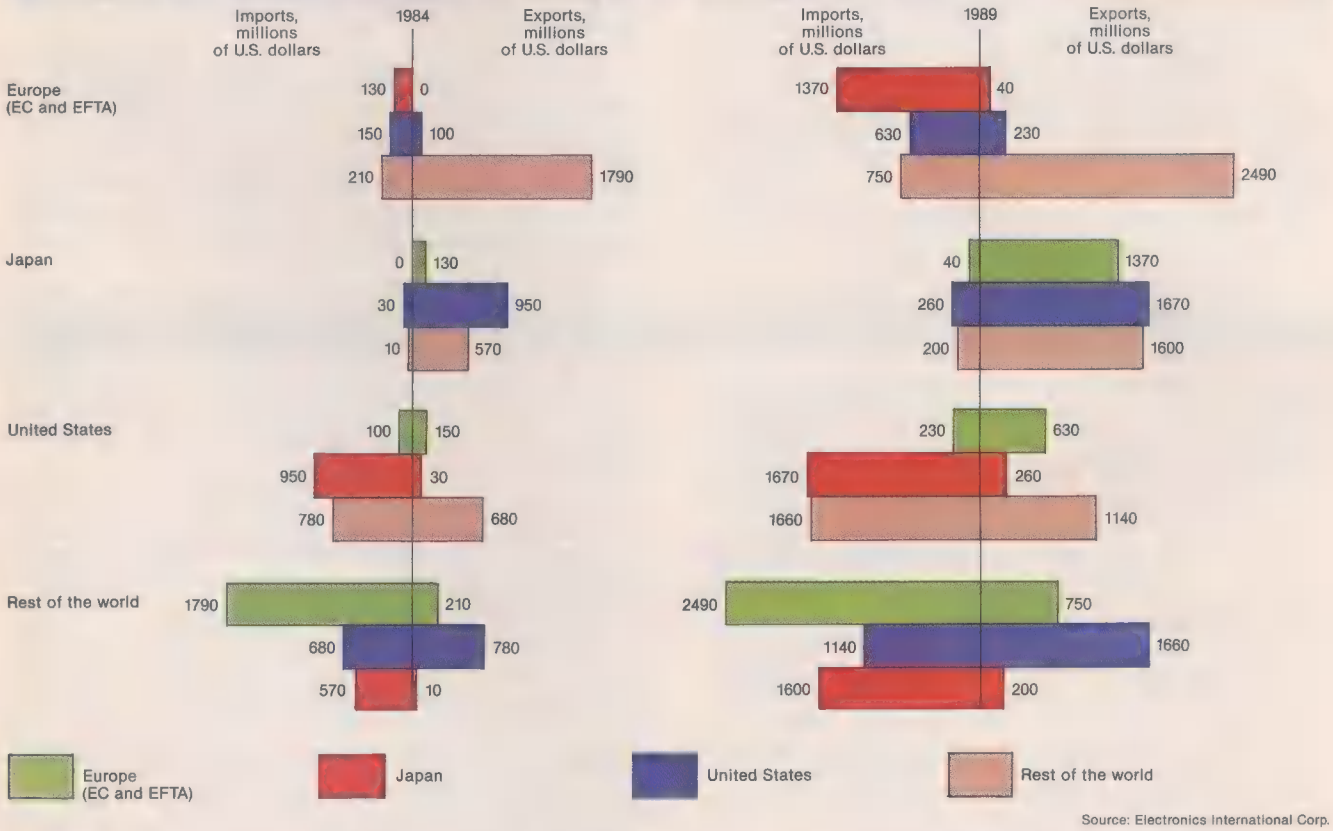
For example, NTT reported the successful transmission of 2.5 gigabits per second over 2200 kilometers of single-mode fiber, using 25 erbium-doped fiber amplifiers. AT&T Bell Laboratories at Holmdel, N.J., reported a recirculating-loop experiment in which solitons (pulses of light so stable they do not spread in an optical fiber) propagated without distortion for more than 10 000 km ["Light that acts like 'natural bits'," *Spectrum*, August 1990 pp. 56–57]. The observed jitter in pulse arrival times was consistent with bit rates up to about 4 Gb/s with a bit error rate of 1 in 10^9. In October, AT&T and KDD announced plans to link the United States and Japan in 1996 with a high-capacity undersea fiber cable boosting the optical signals with erbium-doped fiber amplifiers.

For video distribution with erbium-doped fiber amplifiers, Bell Communications Research Inc. (Bellcore) transmitted 100 FM television signals and six 622-Mb/s data channels to 4096 terminals with a bit-error rate of 10^{-9}. The new amplifiers are even more promising for standard AM television, where higher signal-to-noise ratios are required. For example, NTT reported distributing 19 AM channels from one solid-state laser to more than 12 000 subscribers. The experiment employed six stages of erbium-doped fiber amplifiers and power splitters; the delivered signal-to-noise ratio was 45 decibels, which is good enough for television images to the home.

Meanwhile, for more standard optical-fiber communications, the art of putting many optical channels on one fiber in order to take advantage of the immense available bandwidth is getting closer to practical implementation.

NTT demonstrated the technique, known as wavelength-division multiplexing, with the transmission and distribution of 100 channels over a distance of 50 km using incoherent frequency-shift keying. The signals were sent by 100 temperature-stabilized, directly modulated semiconductor lasers and separated again by tuned optical-filter receivers. AT&T Bell Laboratories demonstrated a technique for stabilizing semiconductor laser frequencies by

International trade in telecommunications, 1984 and 1989



Source: Electronics International Corp.

Balance of trade among Europe, Japan, the United States, and the rest of the world has change significantly over the last five years ■ telecommunications has globalized. Europe was a net exporter in 1984—primarily to the rest of the world—but by 1989 had come to import many of its telecommunications products, especially from Japan. Over the same five years, Japan grew to be the strongest exporter in the world. Between 1984 and 1989, the United States increased its telecommunications imports from Japan, but also from the rest of the world—although that figure also includes products manufactured offshore by U.S.-based companies. The rest of the world has dramatically increased its imports of telecommunications products from Europe and Japan.

New public mobile-communications technologies

	Services			Standards	
Name	Cellular telephony (domestic public cellular-radio telecommunications service)	Personal Communications Network (PCN)	International satellite common-carrier service	Cordless Telephone 2 (CT-2) common-carrier service	Digital European Cordless Telephone (DECT)
Description	Telephone service to and from vehicles and portable transceivers	Complete public-switched wireless phone network for indoor and outdoor use	Network of satellites to route calls from cellular or PCN systems anywhere in the world	UK standard for advanced cordless phones	European Community standard for cordless telecommunications
Technology	Analog FM now; moving to digital TDMA and CDMA; cells 5–8 km across	Digital TDMA or CDMA; "microcells" 100 meters across for maximum frequency reuse; numbers may be assigned to each user, not to each phone	FDMA, TDMA, CDMA under consideration	Digital FDMA, time-division duplex	Digital TDMA, time-division duplex
Frequency band	800 MHz	1800 MHz	Proposed: 20/30 GHz; 2 GHz; 930–931/420–421 MHz; 137/148 MHz	For telepoint (one-way wireless pay-phone service), 40 channels in 864.1–868.1-MHz band; transmitting power of base station and handsets limited to 10 mW	1.8–1.9 GHz
Relation to wireline telephone company	Relies on its own independent switches and on standard telephone network switches	Completely independent and competing network, depending on country's legal structure	Completely independent	Relies on standard phone network for switching	Relies on standard phone network for switching
Status	Commercial	Experimental in United States and Europe	Experimental and some commercial	Standard is incorporated in commercial wireless public pay-phone service called telepoint with one-way (outgoing) calls; two-way systems under development	Standard is still incomplete; DECT-like systems are starting limited commercial deployment
Some participants	Dozens of traditional telephone companies, plus independent cellular companies such as McCaw Cellular Communications	In U.S., 22 experimental licenses granted; in UK, three experimental licenses granted; interest also among cable television firms for linking base stations	AMSC, Ellipsat, Geostar, Leosat, Motorola, NASA, Orbcomm, Qualcomm, Starsys, VITA, among others	Barclay's, British Telecom, Ferranti, France Télécom, Mercury, Motorola, Nynex, Philips, Shaye, Shell, STC	Ericsson, NovAtel, Siemens

CDMA, FDMA, TDMA = code-, frequency-, time-division multiple access
AMSC = American Mobile Satellite Corp.
Barclay's = Barclay's Bank PLC
British Telecom = British Telecommunications PLC
Ellipsat = Ellipsat Corp
Ericsson = Telefonaktiebolaget L.M. Ericsson
Geostar = Geostar Corp.
Leosat = Leosat Corp.
Mercury = Mercury Communications Ltd.
Motorola = Motorola Inc. for internatoinal satellite common carrier service and Motorola Ltd. for CT-2
NASA = National Aeronautics and Space Administration
NovAtel = NovAtel Communications Ltd.
Nynex = Nynex Corp.
Orbcomm = Orbital Communications Corp.
Philips = Philips NV
Qualcomm = Qualcomm Inc.
Shaye = Shaye Communications
Shell = Shell International Petroleum
STC = Standard Telephones & Cables PLC
VITA = Volunteers in Technical Assistance
Source: Benn Kobb; *Federal Communications TechNews*, Washington, D.C.; plus various companies

mode-locking them to the various peaks of a single Fabry-Perot (resonant cavity) filter.

Despite this intense work on wavelength division multiplexing, its widespread application awaits the development of economical optical components, such as integrated heterodyne receivers, integrated multiple-wavelength transmitters, and high-density diode arrays and grating multiwavelength receivers. Erbium-doped fiber amplifiers are clearly a step in the right direction, since they can amplify an entire band of wavelengths at once, eliminating the need for separate electro-optic regeneration for each channel. But much work still remains before coherent optical communications can become a reality.

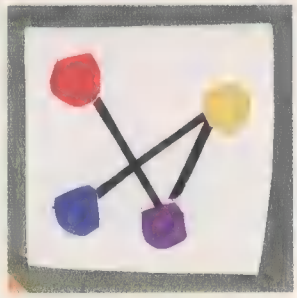
Optical processor demonstrated

In photonic switching for optical computing, last year's major advance was the demonstration by AT&T Bell Laboratories, Holmdel, of a simple optical processor entirely based on optical logic elements and parallel optical connections made through free space rather than through optical waveguides. The optical logic elements were self-electro-optic–effect devices (SEEDs), which operate as NOR gates with optical inputs and outputs. Four two-dimensional arrays, each constructed out of 32 SEEDs, were "connected" by beams of light that were focused through lenses, mirrors, and prisms.

Although the processor could perform only simple tasks such as counting, it showed that free-space optical connections can be used to "wire up" logic systems. Aligning the many beams was relatively easy, suggesting that whole images constructed of parallel beams might be a technically viable way of communicating within processors. Also, by switching all the SEEDs at once, the experiment showed the power of the intrinsic parallelism of optics, which has long been touted as the potential power of optical computing. ◆

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DATA COMMUNICATIONS



Ethernet twisted-pair makes progress
End users, vendors move on FDDI
Interoperability the watchword
Networking at gigabit data rates studied

Two events of great significance occurred in data communications in 1990. One was the rapid acceptance by end users of the new 10BASE-T standard for Ethernet interconnections using unshielded twisted-pair wiring. The other was the widespread acceptance of the Fiber Distributed Data Interface (FDDI) by corporate planners and MIS (management information system) people, as well as government planners, as the way to wire the corporate backbone. And the past year also saw commercialization begin of the FDDI interface by which data is transmitted on an optical-fiber network at 100 megabit-per-second rates.

Twisted-pair wiring for Ethernet local-area networks (LANs) had already been made available in various proprietary configurations. "The business had been growing dramatically without the blessing of a standard," Bill Carrico, president and chief executive officer of Network Computing Devices Inc., Mountain View, Calif., told *IEEE Spectrum*. "But with the standard here, business is going to explode. People will just love using twisted pair, instead of coaxial cable."

As for FDDI, not only were complete chip sets for implementing the interface introduced by at least three semiconductor manufacturers, but a variety of vendors announced or were working on products for that marketplace. A year earlier, potential users could draw on hardware from only a handful of companies, noted Richard Mack, a market analyst at Kessler Marketing Intelligence Inc., Newport, R.I. But in 1990, more than 30 companies showed off networking products for FDDI at a variety of trade shows, he said.

Forrester Research Inc., a market research company in Cambridge, Mass., saw sales of such equipment zooming. It projected a U.S. market for FDDI bridges, routers, hubs, and single-attachment stations soaring to US $453 million in 1993, up from its estimate of $35.5 million in 1990. Forrester also pegged the average per-port cost last year for FDDI, including optical-fiber adapters, hubs, cables, and connectors, at $11 650. The company estimated that this figure will drop to $2000 by 1994.

The products might be expensive, but since they are at the beginning of the production learning curve, that should be expected. "Certainly, they're the harbingers of the mundane technology of five to 10 years from now," said Carrico.

FDDI chip sets

Chip sets for the full FDDI interface were announced by Advanced Micro Devices (AMD) Inc., Sunnyvale, Calif.; National Semiconductor Corp., Santa Clara, Calif.; and Sumitomo Electric Industries Ltd. of Japan. In addition, AT&T Microelectronics, Berkeley Heights, N.J., developed a chip set for a partial FDDI interface, and Digital Equipment Corp., Maynard, Mass., developed one that is to be second-sourced by AMD and Motorola Inc., Schaumburg, Ill.

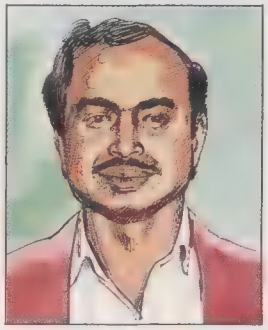
In large volume, the price of a complete chip set might be around $250, said Sanjay Dhawan, manager of AMD's Advanced Networking Technology Center. But he sees this price falling to under $100 in 1992 when the chip is produced in "real volume," once the technology is applied to the desktop computer.

Alfred Rosenblatt Technical Editor

AMD found enough interest in FDDI technology to establish its networking center last July. Its purpose: to develop programs for testing FDDI LAN products and to carry out the tests. A similar facility, the Interoperability Laboratory, is also in place in the Research Computing Division at the University of New Hampshire in Durham. That laboratory, which began its FDDI test program for an industry consortium last June, had set up a similar group last January for testing 10BASE-T products, and is considering organizing interoperability tests of other networking products.

An interoperability facility is particularly needed for FDDI—only time will tell if two are needed—because FDDI developed differently from Digital Equipment's Ethernet or IBM's Token

DATA COMMUNICATIONS, TELECOMMUNICATIONS CONVERGE



DIPANKAR RAYCHAUDHURI: EXPERT OPINION

'High-performance workstations and distributed processing systems [have] increased the demand for packet networks with improved bit rates and response time.'

The most notable trend of the past year was an acceleration of the convergence between data communication and telecommunication technology. This growing overlap between two formerly distinctive communication scenarios has been driven by a combination of "application-push" and "technology-pull."

On the application side, the recent proliferation of high-performance workstations and distributed-processing systems has increased the demand for packet networks with improved bit rate and response time. In addition, recent advances in computer and signal-processing technology have led to the emergence of multimedia applications incorporating a combination of voice, data, and video.

As multimedia and related technologies (such as workstation teleconferencing, image retrieval/transfer, and voice e-mail) become more pervasive, data communication systems have evolved from the low-to-medium-speed datagram networks of the 1970s and 1980s to general-purpose telecommunication networks handling a wide range of bit-rate/delay requirements for both real-time and non–real-time data traffic.

On the technology side, the convergence of data communications and telecommunications can be attributed to increasing acceptance of a new generation of packet-switching technology over circuit switching. Packet communications offers important advantages, such as resource sharing, service integration, variable-bit-rate (VBR) service flexibility, burst traffic support, multipoint-to-multipoint operation, and lower switching cost per subscriber. Technical difficulties associated with the previous generation of packet networks—such as insufficient bit-rate throughput, high variable delay, and/or packet loss—inhibited their application to such real-time services as voice and video.

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Ring. With the latter two, the products came first, while for FDDI, the standard, the American National Standards Institute's ANSI X3T9.5, came first. When Ethernet and Token Ring moved to standardization, manufacturers already knew how to make the products.

With FDDI, equipment vendors needed to learn how to make them, and they realized the importance of having them work together seamlessly. No longer can a single vendor produce a product and have it under his own control, noted the Interoperability Laboratory's director, Barry Reinhold, adding that "remote software services require lots of things to work right, and they're made by different people."

His center's goals, said Dhawan, are to help vendors test the interoperability of their products and to build confidence among end users that FDDI is truly multivendor. By year-end, the center had 28 members, including equipment vendors Cisco Systems, Codenoll Technology, Hewlett-Packard, Interphase, Martin Marietta Aero & Naval Systems, Datensysteme, Sun Microsystems, SynOptics Communications, and Ungermann-Bass, as well as a chip maker, Sumitomo Electric.

New Hampshire's Interoperability Lab had more than 20 members, most from the East Coast and including IBM, Motorola, National Semiconductor, and the Apollo Systems operation acquired by Hewlett-Packard. Another purpose of the laboratory is to train the university's students in the latest networking technology, added Reinhold.

Equipment vendors were not content, however, to rest with optical fiber as the only means of carrying FDDI's data rate. Rochester, N.Y.–based Cabletron Systems Inc. marketing manager Michael Welts pointed to research showing that 95 percent of all network connections fall within 100 meters of the wiring closet, while the FDDI standard requires an interface supporting distances out to 2 kilometers.

FDDI on twisted-pair

"In essence, this becomes overkill, and over-expensive," Welts said. "Users only need 100 meters of cabling, and twisted-pair can provide this capability in the most cost-efficient means possible." The average per-port cost for twisted-pair FDDI connections would fall well below the Forrester Research's $2000 figure, he said, if a twisted-pair standard were approved.

Last August, Cabletron said it had developed the technology for twisted-pair FDDI and was joining with National Semiconductor to develop an integrated-circuit twisted-pair FDDI transceiver interface that Cabletron would design into its product line. Also active was SynOptics Communications, Santa Clara, Calif., which signed a technology agreement with four strategic partners—CMC (Communication Machinery Corp.), a Rockwell International Corp. company, Interphase, Network Peripherals, and Silicon Graphics—to find applications for a board-level twisted-pair FDDI transceiver that SynOptics had developed.

And in October, SynOptics and its partners demonstrated the technology for running the FDDI protocol over IBM Type 1 shielded twisted-pair at the Interop 90 Show in San Jose, Calif.

With the gradual application of broadband media to data communications, it became clear that high-speed local-, metropolitan-, and wide-area networks (LANs, MANs, and WANs) could support much more than just data if suitable fast packet-switching protocols were developed. Fast packet-switching methods such as frame relay and cell relay are now being applied to LAN interconnection, and are also applicable to integrated voice/video/data multimedia traffic.

The telecommunication world has also been embracing fast packet-switching concepts to provide flexible, high-bit-rate services. The cell-relay–based IEEE 802.6 MAN standard is being employed for new switched multimegabit data services (SMDS) offered by telephone companies. A longer-term move of this nature is evidenced by the selection of asynchronous transfer mode (ATM) as the target world standard for the broadband integrated-services digital network (B-ISDN).

High-speed LANs, MANs, and WANs supporting a wide range of bit rates and service quality levels are the basic prerequisite for the emerging integrated communication scenario. The past year has seen considerable progress in standardization and commercial development of high-speed LANs and MANs. The Fiber Distributed Data Interface (FDDI), operating at speeds up to 100 megabits per second, also became widely available. It is being used to satisfy growing demand for high-speed packet-switched backbone networks able to interconnect many LANs, while also providing adequate throughput to such high-bit-rate devices as supercomputers and full-motion video systems.

Parallel to FDDI, the higher-speed IEEE 802.6 MAN standard effort has reached sufficient maturity to permit early commercial development of SMDS. Prototype switched-star ATM networks with 155.5-Mb/s access line speeds have also been demonstrated this past year. In addition, several promising very high-speed (over 1 gigabit per second) optical-fiber LAN and MAN approaches, based on recent progress with wavelength-division multiplexing (WDM) and/or optical switching components, are currently at various stages of R&D. At the same time, the push for gigabit wide-area packet networks is increasing with major research initiatives by both government and industry.

Fast packet protocols are the second key element in the data communication scenario of the 1990s. Considerable progress has been made in the specification of frame- and cell-relay protocols, which simplify (and hence speed up) normal packet switching procedures by limiting or eliminating error-control and flow-control overheads. Frame-relay protocols such as LAPD/Q.921 have been standardized by the CCITT, while cell-relay protocols such as IEEE 802.6 and ATM (along with associated Sonet transport) have either been defined or are close to final definition. While LAPD and 802.6 each occupy relatively well-defined application areas, ATM is broadly applicable to all data and telecommunication services. Service-specific ATM adaptation level (AAL) protocols for various applications such as voice, TV/HDTV (high-definition TV) delivery, and data are currently under consideration by standards groups.

Higher-level session and presentation level protocols for multimedia are at a relatively early stage, and further development will be required before the full potential of broadband networks can be commercially realized. ATM may indeed be the answer to the fast-changing integrated-service requirements of both the data communication and telecommunication scenarios, although it will be a while before an industrywide consensus is reached in the United States.

Another development worth noting is the new interest in wireless technologies for data network applications. Wireless LAN/MAN technologies have initially been driven by reconfigurability/cost advantages in niche markets, but they could evolve toward serving the growth in the demand for personal data communications. As personal computer applications such as e-mail and multimedia proliferate, data may become an integral part of personal/mobile communications, dominated by voice services.

On the spectrum-limited radio medium, a resource-shared data communication service such as e-mail-type messaging is orders of magnitude more bandwidth-efficient than voice. It can provide essential connectivity at a very low cost per subscriber. Technology for wireless data services can be based either on the digital time-division, multiple-access (TDMA) transport to be used in next-generation cellular mobile radio or on the lower-power, wider-band spread-spectrum approaches announced recently. Spread-spectrum networks, very appealing for their spectrum allocation and compatibility advantages, also appear to be promising for wireless LANs and MANs, which efficiently support large numbers of bursty data terminals.

Dipankar Raychaudhuri (SM) is head of broadband communications research at the David Sarnoff Research Center, Princeton, N.J. He is currently chairman of the IEEE Computer Society Committee on Data Communication Systems, and is an editor of its Communications *magazine.*

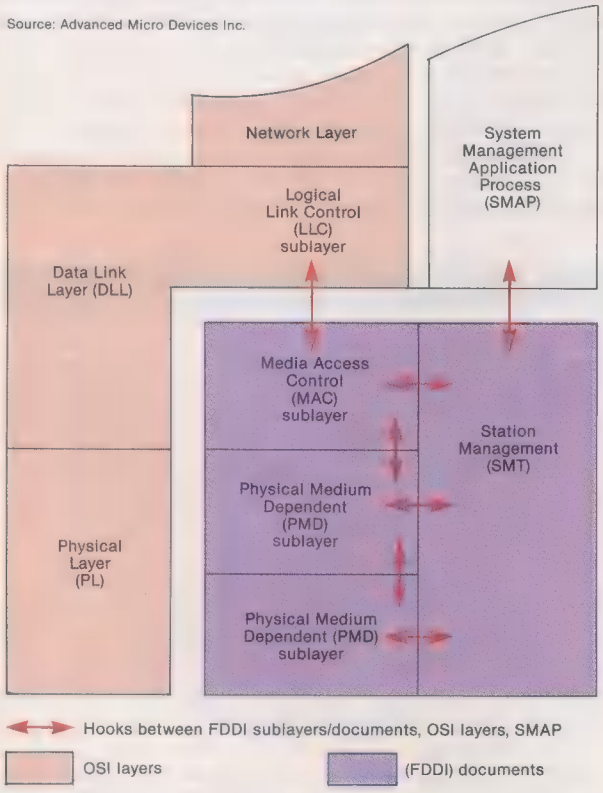
At the core of the demonstration was SynOptics' LattisNet System 3000 intelligent wiring center, or hub, which supports Ethernet, Token Ring, and FDDI. New products could result within the next six to 12 months, according to the company. However, whether the FDDI drops from the wiring closet will rely on shielded or unshielded twisted-pair is still being debated.

As for the transceivers, Hewlett-Packard Co., Palo Alto, Calif., was the first partner to deliver late last year on a multisourcing agreement it signed in 1989 with AT&T Co. and Siemens AG. The price for the HPBR-5125 was hefty, however—$550 in quantities of one to nine, with volume prices negotiable.

Integrating Ethernet, Token Ring, FDDI

The development of twisted-pair wiring for Ethernet and FDDI signals the onset of a far-reaching change in LANs, said Steven Moustakas, SynOptics' director of product management.

"In the year ahead, we'll start to tie together Ethernet, Token Ring, and FDDI local networks in one concentrator in one wiring closet," he explained. "We'll be able to make a single, more productive network out of the islands of networking that have been developed in many companies over the years—for example, Ethernet used for engineering and Token Ring for finance. And we'll be doing it with structured wiring systems such as AT&T's PDS [premises distribution system] for 10BASE-T Ethernet and IBM's shielded twisted-pair cabling system for Token Ring." Tying those networks together will be bridges and routers included in that wire-closet concentrator.



With the document for the Station Management, or SMT, sublayer finalized last year by ANSI's X3T9.5 standards committee, the 100-megahertz Fiber Distributed Data Interface (FDDI) began to attract lots of vendor and end-user attention. The SMT, where error detection, fault isolation, and correction algorithms are defined, provides the intelligence for the FDDI sublayers to work together. It falls outside the OSI seven-layer model, but FDDI's other sublayers are concerned with the two lowest layers of the OSI model.

As for the network itself, it is often a network of networks, and is becoming multivendor, mixing hardware and software from different vendors. Macintosh LANs, for example, which have traditionally been made up only of other MACs, can now interconnect with Digital Equipment Co. VAX and DOS- or OS/2-based machines.

Managing such an integrated network will be handled with another item that boomed in 1990, according to Dan Lynch, president of Interop Inc., the Mountain View, Calif., company that organizes the Interop shows. Lynch referred to the Simple Network Management Protocol (SNMP), which originated in the Transmission Control Protocol/Internet Protocol (TCP/IP) world about a year and a half ago. It allows for standards-based management of LANs up to layer 3 of the Open Systems Interconnection (OSI) protocol. Fifty vendors were at the Interop show demonstrating SNMP. The protocol permits applications to be written across heterogeneous systems so that network operations people can have a coherent set of tools to probe their entire network.

These tools include products from multiple vendors, because more vendors than ever are publishing the details—the management information base, or MIB—needed for a customer to manage concentrators from multiple vendors, said Moustakas of SynOptics. His firm introduced its first SNMP management system last year with its LattisNet System 3000.

Another important development in LAN interconnection is that a consortium of manufacturers, led by Cisco Systems Inc., Menlo Park, Calif., and Stratacom Inc., Campbell, Calif., have agreed to implementation standards for the frame relay protocol. Frame-relay-based subnetworks may in many cases provide far better price-performance than point-to-point or X.25-based subnetworks.

'LAN' may no longer apply

Actually, the connectivity and complexity of the burgeoning LAN market may have outgrown the term "LAN." It used to be that the LAN market could be clearly segmented—for example, by function, by the organizational level being connected (from workgroup PC cluster up through department levels to a mainframe host), or by the dominant network technology: baseband, broadband, token ring, and so on.

But that kind of segmentation means less and less in today's ever more complex connectivity environment, pointed out market researcher Frost & Sullivan Inc., New York City. Today, those segments all overlap, as stand-alone workgroup LANs become more like general-purpose LANs and connect into wide-area networks. The market may be more aptly defined by the term "network computing," according to Frost & Sullivan.

The market researcher predicted in a report last year booming growth for the subnetwork LAN market. Total LAN sales for offices in the United States, for example—hardware, software, and cabling—amounted to over $5.68 billion in 1989, and Frost & Sullivan forecasts this total will reach $16.99 billion in 1994 (in constant 1989 dollars). In this time frame, hardware sales are predicted to go from $4.06 billion to almost $11.3 billion; software sales from $883 million to $3.77 billion; and media sales from $720 million to nearly $1.8 billion.

What's more, this dollar growth will take place despite a continuing decline in average prices. During the forecast period, expanding connectivity will increase the size of the average LAN from nine to 16 nodes. However, the cost of a single node will decline by 51 percent, from $766 in 1989 to $376 by 1994, as LANs grow larger and the costs of centrally shared resources such as servers and printers are spread over more nodes. The average cost per LAN (hardware and software, but not including media) will drop 19 percent, from $6893 to $5606.

At the highest data rates

With the commercial world ready for operation at data rates of 100 Mbits/s and beyond, the research community is jumping to an order of magnitude higher—1 Gigabit/s and up. For example, last September Advanced Network & Services (ANS) Inc.,

Elmsford, N.Y., was established to meet the skyrocketing demand for high-speed networking and help propel network capabilities into the next century for the U.S. research and education communities.

The new organization's efforts will be not only in research and development needed for gigabit-per-second data transmission—it has also taken on the management and operation of the Government-funded National Science Foundation Network (NSFnet) backbone, under subcontract to Merit Inc., Ann Arbor, Mich. Merit and its corporate partners, IBM Corp. and MCI Communications Corp., Washington, D.C., had managed and operated the NSFnet since 1987. In providing for gigabit data rates, ANS will build on the research and testbed activities currently under way at various organizations.

Researchers also have their sights set on developing a new generation of protocols for high-performance networks. "You might predict there'd be little interest in such research because of the difficulties in arriving at standards," said Greg Chesson, chief scientist for Silicon Graphics' computer systems service, based in Mountain View, Calif. "But, judging by the attention it received at the International Federation of Information Processing Societies' conference in November, protocol research is alive and well."

Chesson's own work has gone into developing the Xpress Transfer Protocol, or XTP. This protocol minimizes overheads by, for example, minimizing handshaking and setting up a fixed packet structure. To achieve high speed, Chesson envisions a protocol "engine" implemented in very large-scale integrated (VLSI) chips, instead of in the usual software, to carry out the requirements of layers 3 and 4 of the OSI reference model.

In another protocol effort, a European consortium led by Jacques Levasseur of Bull SA, Louveciennes, France, received the go-ahead from the European Community's Esprit (European Strategic Programme for Research and Development in Information Technologies) organization to revisit OSI model layers 3 to 7. The group's goal is to design a high-performance protocol for the communications and application environments expected in the mid- to late 1990s.

Designated OSI 95, the project is focusing on high-speed LANs, metropolitan- and wide-area networks, and broadband integrated-services digital networks (B-ISDNs). High-performance applications include multimedia transmissions composed of voice, text, image, and video, and distributed computing systems. The OSI standards do not meet the requirements of these applications at present.

The first major step in the two-year project, begun late last October, is the design, specification, and validation of a transport-internet protocol called TPX. Using the standard Logic Link Control (LLC) type 1 service and offering standard transport connection-mode service, TPX will be based on the current OSI standards to facilitate migration. Its design will take into account as many criteria as possible aimed at simplifying implementation in silicon.

Chesson noted that the different groups working on the advanced protocols tend to be in close communication and share their results. He predicts that a consensus among the groups is very likely to emerge within the time frame of OSI 95.

HIGHLIGHTS

Success: The welcome given the 10BASE-T standard for Ethernet unshielded twisted-pair augured a flood of networks of that type.

Shortfall: A bug in switching software last January kept AT&T Co.'s network from handling half its normal volume of calls for nine hours—a glitch heard round the world.

Notable: The convergence of data communications and telecommunications accelerated.

Newsmaker: The standard for the 100-megabit-per-second Fiber Digital Data Interface, which was completed by the American National Standards Institute *before* many different and incompatible products could be developed.

Further impact on OSI

The seven layers of the OSI protocol also received a big boost last year from the U.S. government, and it will likely become the routine way of organizing data networks worldwide, pointed out an industry consultant specializing in OSI matters, Richard desJardins of Annapolis, Md. This latest impetus for OSI comes from Federal Information Processing Standard (FIPS) No. 146 , *Government Open Systems Interconnection Profile* (Gosip), which became mandatory last Aug. 15 for new systems procurements and upgrades for all Federal agencies.

The Gosip master plan calls for 90 percent of Government equipment to be OSI-capable by the end of the decade, 50 percent by the middle of the decade. At present, only about 5 percent of the networked equipment is OSI-capable.

Manufacturers are committed to providing OSI/Gosip products, said desJardins. Again, the Interop 90 Show in San Jose last October provided the evidence when 22 vendors networked their OSI products with each other and with locations abroad, he indicated. They used OSInet, the OSI implementers' X.25 network in the United States, as well as the Ethernet network at the show, and demonstrated X.400 message handling and FTAM file transfer.

The era of OSI will receive another boost, continued desJardins, as the national Internet, now based on TCP/IP, implements its OSI coexistence plan and becomes more internationally oriented. The National Science Foundation's NSFnet, the Internet backbone, is already supporting CLNP, the OSI Connectionless Network Protocol that is equivalent to the IP Internet Protocol. This arrangement provides a multiprotocol backbone sub-network that allows both OSI and TCP/IP parts of the Internet to coexist over the same routing hardware and transmission links,. Thus another step is taken toward facilitating evolution to OSI as time goes on.

Information on a global scale

Fiber cabling carrying gigabit data rates and the metropolitan-area network (MAN) defined in the IEEE's 802.6 standard will both play a critical role in changing the way corporations are wired. These two technologies will encourage large data users to move away from proprietary systems.

According to Steve Bell, manager of the LAN business development group at National Semiconductor, great strides were made in 1990 by the 802.6 MAN standards committee toward well-thought-out techniques for interconnecting the LAN environment to the wide-area public-network environment. And in the WAN community, the idea of the fast-packet-switching ATM (Asynchronous Transfer Mode) transmission technique has been "well shaken out" by the worldwide technical research and development community, he said, with great progress made in ANSI toward standardization.

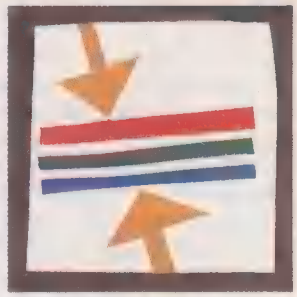
"Globally, we're moving toward a single, public networking environment built upon an infrastructure of gigabit-speed fiber optic links, defined at the physical layer by the Sonet standard," Bell continued. The Sonet (Synchronous Optical Network) standard defines common timing for high-speed networks, ranging in speed from tens of megabits to tens of gigabits per second, and provides the mechanisms for easily multiplexing and demultiplexing low-bit-rate data in and out of a high-speed trunk without requiring several layers of a complex channel-bank equipment hierarchy.

Ultimate networking environment

In just 10 years, distances and time zones between computers will become much less important, as they begin to access one another within a global "single environment" using common protocols over a series of internetworked global fast packet-switched ATM networks, Bell said. Sonet, 802.6 ATM, and B-ISDN will become the ultimate networking environment to share multimedia voice, video, and data in one, integrated wide-area environment.

For a perspective on what is in store for the future, consider this from Bell: "If networking and communications today were the automobile industry, this would be 1915."

SOLID STATE



Passing the 2-million-transistor mark
Digital signal processors are on the march
Enter the multimedia chip
Photolithography lives on

Last year saw the commercial introduction of microprocessor chips containing more than 1 million transistors and 1991 will probably see microprocessor chips with well over 2 million transistors. Processor speeds are keeping pace; 50–60-megahertz chips can be expected in the next generation as 1990's 25 MHz becomes taken for granted.

Memory chips, too, grow bigger and faster. Dynamic RAMs, for example, are being shipped in volume in 4M-bit sizes; 16M-bit DRAMs are being sampled; 64-Mbit devices have been demonstrated ["The Main Event," p. 30]; 256-Mbit and even 1-Gbit devices are in development. Their access times, meanwhile, are falling steadily; where about 80 nanoseconds is standard now, about 60 ns will be the norm a year from now with standard CMOS technology, and 35 ns may be reached with bipolar-CMOS (biCMOS).

A major beneficiary of the rising integration-performance curve is portable electronic equipment of all kinds. Not just desktop computers but laptop, notebook, and palmtop machines are losing weight and consuming less power. In the offing are digital cellular telephones no bigger than a pack of cards.

Microprocessors with memory

An example of higher integration at the high end of processor products is an 80386 variant that Intel Corp., Santa Clara, Calif., designed for notebook-sized personal computers. The 386 SL integrates a 386 processor with cache and main memory controllers, mapping logic, bus and coprocessor interfaces, and power conservation logic. To go with the integrated processor chip, Intel offers a peripheral subsystem chip that includes, among many functions, a power management system that saves battery power. Together, the two ICs provide almost all the elements for an IBM PC/AT-compatible desktop computer—but on a circuit board of only 4 by 6 inches (10 by 15 centimeters).

Reduced-instruction-set computer (RISC) microprocessors remain controversial, although resistance to them is thawing. Major U.S. semiconductor houses offer them in megatransistor chips. For one, Motorola Inc.'s Semiconductor Products Sector, in Phoenix, Ariz., plans to introduce a more highly integrated version this year, when it adds cache memory to its RISC processor. IBM Corp., which makes both RISC and CISC (complex-instruction-set computer) microprocessors for its own use, sees a role for both. Big Blue is pleased with the performance of RISC architecture, now in its second generation, in its 6000 series of workstations.

"RISC makes it easier to take advantage of high densities and complex wiring," said Luis Arzubi, assistant site general manager at the company's Burlington, Vt., semiconductor manufacturing plant. "But CISC will be around for a long while because of the many applications and many, many lines of code that have been written for it." In fact, Arzubi sees CISC chips borrowing features from RISC. "CISC on-board caches are larger and buses are wider because of RISC," he said.

RISC microprocessors are rapidly taking hold in embedded applications. Intel recently introduced a low-cost version of its i960 32-bit chip. Priced at US $20, the highly integrated i960 S series costs about the same as many 16-bit microprocessors. The chip includes a 512-byte instruction cache, an interrupt controller, full address space, register sets, and a data bus. It is intended for such uses as disk controllers, network adapters, color copiers, printers, and facsimile machines.

Embedded applications in general continue to grow, especially for 16-bit microcontrollers, which, just like high-end microprocessors, are becoming more highly integrated and gaining in functionality. Manufacturers of automobiles, appliances, and industrial controls, for example, are upgrading from 8-bit to 16-bit control for faster response, and semiconductor manufacturers are making it easy for them by offering 16-bit microcontrollers that can use the same source code as their 8-bit predecessors. Motorola's 68HC16, to become available early this year, can operate on the same software as the 8-bit 68HC11. The new unit, moreover, includes digital signal processing as well as on-chip peripheral functions. Chrysler Corp., Highland Park, Mich., will use the new device in engine control.

Intel, too, in its new 16-bit microcontroller offerings, includes versions with 8-bit buses and provides adaptation tools so that equipment designers can upgrade without losing software investments.

High integration levels are permeating even low-end microcontrollers. Motorola developed a version of its 8-bit 68HC05 for Apple Computer Inc., Cupertino, Calif., that includes a phase-locked-loop oscillator, a clock-interrupt circuit, and 364 bytes of RAM as well as a central processing unit (CPU). Apple uses the chip in its low-cost Macintosh LC and [PI]si machines. Motorola is now offering the chip as a standard product.

Image processing is a prime application of embedded high-end CISC microprocessors, just as it is for embedded RISC microprocessors. National Semiconductor Corp., Santa Clara, Calif., for example, introduced the 32-bit NS32GX320, which, in addition to a CPU, includes digital signal processing, concurrent processing, direct memory access (DMA) control, programmable timing, and 15-level interrupt control. Its high level of integration can reduce component count by 20 percent, board space and power consumption by 25 percent, and equipment cost by up to 30 percent, its developers say. Russell Johnsen, director of National's imaging group, foresees its use in multifunctional desktop imaging units that combine fax, printing, scanning, and copying—and even voice mail.

DSP catching up

Digital signal processor (DSP) chips are adding enormous functionality to desktop computers and workstations. Many foresee that a DSP chip will eventually have equal status with the microprocessor in these units. Anne C. Schowe, director of market development with AT&T Microelectronics, Berkeley Heights, N.J., predicts that by 1992, high-resolution graphics and video will be common in PCs, and perhaps by 1995, PC-based video conferencing with TV-quality images will be taken for granted.

To this end, AT&T announced a low-cost "multimedia" chip, the DSP3210, that can provide video images and high-quality graphics on the screen and, simultaneously, high-quality sound.

George F. Watson Senior Editor

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It is directly compatible with Intel's and Motorola's 32-bit microprocessors. The chip is expected to be available in sample quantities in June and in volume production by the end of 1991 at a price of $50. Schowe promised more DSP product announcements this year.

Motorola and Texas Instruments Inc., Dallas, offer a variety of DSPs, including some recently announced high-performance chips. TI's TMS320C31 is a highly integrated device that makes the accuracy and dynamic range of floating-point operations affordable in applications that have had to rely on fixed-point computation until now. Applications include high-speed modems, voice recognition, transcoders, robot control, hard-disk control, as well as multimedia. Samples of the 26-MHz clock rate chip are now available for $35. The company expects to introduce a 33-MHz version early in the year.

Motorola's top-of-the-line DSP, the 96002, is a 32-bit floating-point version of the company's 24-bit 56001, which is widely used in digital audio electronics. The 32-bit chip is designed for full-motion-video compression and decompression, animation, color printing and facsimile, as well as data telecommunication. Both 27- and 33-MHz versions are in volume production, and a 40-MHz version will be available sometime during the first half of this year. The 27-MHz unit costs $200.

HIGHLIGHTS

Success: Memories set the pace as the 4M-bit generation of dynamic RAM chips was produced in volume and the 16M-bit generation was sampled widely.

Shortfall: Efforts to spur national and supranational cooperation in the manufacture of advanced memories suffered setbacks. A U.S. consortium, U.S. Memories Inc., fell apart over financing. A European consortium of chip manufacturers and governments, Jessi, was hurt by Philips' decision to cut back its IC work.

Notable: Companies allied to share the staggering costs of developing and producing ICs: IBM with Siemens, AT&T with NEC, Texas Instruments with Hitachi, Motorola with Toshiba.

Newsmaker: William J. Spencer who took over as president and chief executive officer at Sematech when Robert N. Noyce, coinventor of the IC, died. Spencer came to the manufacturing technology consortium from Xerox Corp., where he was vice president and senior technical officer in the corporate research group.

Memories grow

Flash memories grow in popularity; many see these nonvolatile, reprogrammable devices eventually supplanting hard and floppy disks—in fact, they may be the only choice for palmtop computers. Advanced Micro Devices Inc. (AMD), Sunnyvale, Calif., joined the ranks of suppliers with a 1M-bit flash memory having the low access time of 90 ns compared with the usual 120 or 150 ns. Price is less than $10. AMD promises a 2M-bit device before July.

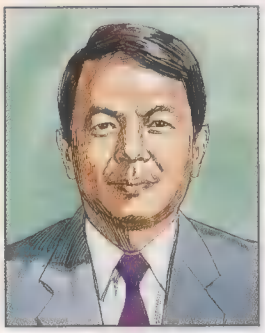
Intel makes a flash memory card containing an array of ultraviolet-light-erasable programmable ROM (EPROM) tunnel oxide devices in a package with the same length and width as a credit card and only about four times the thickness. Inserted in a portable computer, the card can be downloaded from a desktop to provide lightweight, low-power storage for application code, data files, and data acquisition. The card has either 1M- or 4M-bit capacity. Intel notes that its mean time between failures is 1 million hours vs. 50 000 hours for a mechanical disk drive. Fujitsu Ltd., Kawasaki, Japan, will also make the Intel flash memory card.

RAM manufacturers are racing harder than ever to be first with the biggest or fastest. In dynamic RAMs (DRAMs), 1M-bit chips are commonplace. Second-generation 4M-bit DRAMs are now in volume production with improved characteristics—faster access times, for example. Hitachi Ltd. and Toshiba Corp., both in Tokyo, now make 4M-bit DRAMs on smaller chips with an access time of 60 ns—20 ns shorter than their predecessors.

The first 16M-bit DRAMs are reaching equipment developers. Samsung Electronics Co. in Seoul, South Korea, and Toshiba announced availability of samples in late summer. Texas Instruments and Hitachi joined them in November, as did NEC Electronics, Tokyo, in December. The next giant step is 64M bits, as the pace accelerates, and experimental prototypes have started to appear.

Static RAMs, valued for their speed but hampered by their relatively large cell size, lag a generation behind DRAMs in capaci-

STREAMLINING MANUFACTURING



SHOJIRO ASAI: EXPERT OPINION

'Mass-producers of semiconductors will have to streamline their operations to survive in this decade.'

The 1990s will see large, extremely high-speed, high-data-rate electronic systems on the one hand and marvelously compact, mobile, lightweight electronics on the other. The latter will exert a larger influence by far on the market and on people's lives. This presents us with a challenge: what kind of integrated circuits shall we build to meet the needs of the '90s? There will be no unique answer; it will depend on each company's business emphasis. And so we will see such IC variations as high-speed microprocessors with increased parallelism, high-definition video chips with analog and memory interfaces, voice processor chips with adaptive recognition capability, mobile communication chips with low power consumption, intelligent power ICs for vehicle control, and, of course, plain old memories. We will also see more and more of these functions integrated on a single chip.

As always, the true challenge is product definition, but with the enhanced resources of 1990s microelectronics, it is more acute; business decisions are inextricably entwined with the technology outlook: what new technology is coming and when? The designer who matches what people want (consciously or unconsciously) with what emerging technologies can do will exploit the potential of the 1990s to the fullest. And the combined potential of those technologies—flash memory, multichip packaging, low-voltage circuits, heterojunction devices, optical interconnections, and redundancy techniques, to name a few—is vast.

A perhaps more daunting challenge than meeting the challenge of product definition is the need to streamline manufacturing. We must reduce the heavy capital investment for new, advanced semiconductor plants and increase the efficiency with which we run them. Progress in manufacturing technology and equipment has been stunningly fast, but it has been process-specific; it has left us with cluttered pieces of different types of equipment in large, expensive clean rooms. To a large extent, this legacy accounts for soaring capital expenses. We must find ways to integrate independent process modules efficiently, increase throughput, and thereby reduce our costs.

Some argue that robots and clean containers—rather than clean rooms—will help us utilize equipment more efficiently. Others have begun looking at clustered tools for several process modules to form a multichamber machine that would help to minimize defects and maximize efficiency. In the effort to eliminate clean rooms, some engineers have been transporting wafers on air bearings in clean tunnels, with some success.

And, of course, computer control will play a key role in integrating manufacturing. Whatever the solution, mass-producers of semiconductors will have to streamline their operations to survive in this decade.

Shojiro Asai (F) is deputy general manager and directing manager of the ULSI Research Center, part of Hitachi Ltd.'s Central Research Laboratory in Tokyo. He received B.S., M.S., and Ph.D. degrees in applied physics from the University of Tokyo, in 1963, 1965, and 1970, respectively.

He has worked on semiconductor device physics and modeling, microfabrication technology, reliability problems, has written about 50 technical papers, and has won numerous awards, including the best panel award at the 1989 ISSCC.

ty. The 1M-bit SRAM occupies ■ position like 4M-bit DRAMs; manufacturers are refining the product. Toshiba now offers a 256K-bit device with ■ 17-ns access time, for example.

One-megabit SRAMs are available from such companies as Hitachi, Samsung, NEC Electronics, Motorola, and VLSI Technology Inc., San Jose, Calif. VLSI's device, which it developed jointly with Hitachi, gives access to data in 35 ■■ and dissipates extremely low power—350 milliwatts in active mode, 100 microwatts in standby. It is intended for large cache memories. Motorola reportedly is testing its 1M-bit SRAM at 25 ns.

Toshiba announced an operating prototype 4M-bit SRAM. The CMOS memory uses thin-film transistors and 0.5-micrometer lithography to cram the memory cells on a tiny 7.8-by-17.4-millimeter chip. Each cell is overlaid by two thin-film transistors, which lie in an oxide film over the chip instead of side by side with the other four transistors. Toshiba measures a 23-ns access time.

Logic topics

Microprocessors and memories, of course, do not exist independently; they are tied together by logic, and here, too, the combined forces of chip expansion and geometry contraction are at work. Gate arrays, programmable-logic devices (PLDs), and so forth, grow steadily in their numbers of cells.

NCR Corp., San Jose, Calif., has gone into production with its submicrometer CMOS gate-array series, VGX700, with up to 169 000 gates per chip. Typical delay for a two-input NAND gate with a fanout of two is 390 picoseconds.

Motorola will introduce this year its H4C series in CMOS arrays of up to 318 000 available gates—three times the number in its previous gate array family. Chips with up to 195 000 gates will become available in April; the full 318 000 gates will become available sometime in the second half of the year. With a gate speed of 180 ps, the series is fast enough for 60-MHz processors. A key advantage of large arrays, according to Douglas Powell, Motorola's vice president and director of technology and planning for the company's operations in Phoenix, Ariz., is that equipment suppliers can use them to add distinctive, customized features to highly integrated microprocessors with on-board cache memory.

TI went into production with fast PLDs—maximum propagation time is 5 ns, versus 7 ns for the previous generation. Minimum cycle time is 125 MHz. The bipolar chips are in 20- and 24-pin versions.

Fujitsu is manufacturing high-density emitter-coupled logic (ECL) gate arrays with on-chip memory. The chips contain about 14 500 gates with speeds of 80 ps unloaded, 250–350 ps loaded, and an address access time of 3 ns. One version holds 40K bits of RAM; the other, 160K bits of ROM.

Analog Devices Inc., Norwood, Mass., succeeded in combining high-performance analog-to-digital and digital-to-analog converters with its DSPs by adopting a primarily digital approach to conversion. The problem has been that conversion circuitry requires a different kind of IC processing from the CMOS processes used for DSPs; attempts to form both conversion and DSP circuitry in the same chip meant that one or the other—or both—suffered.

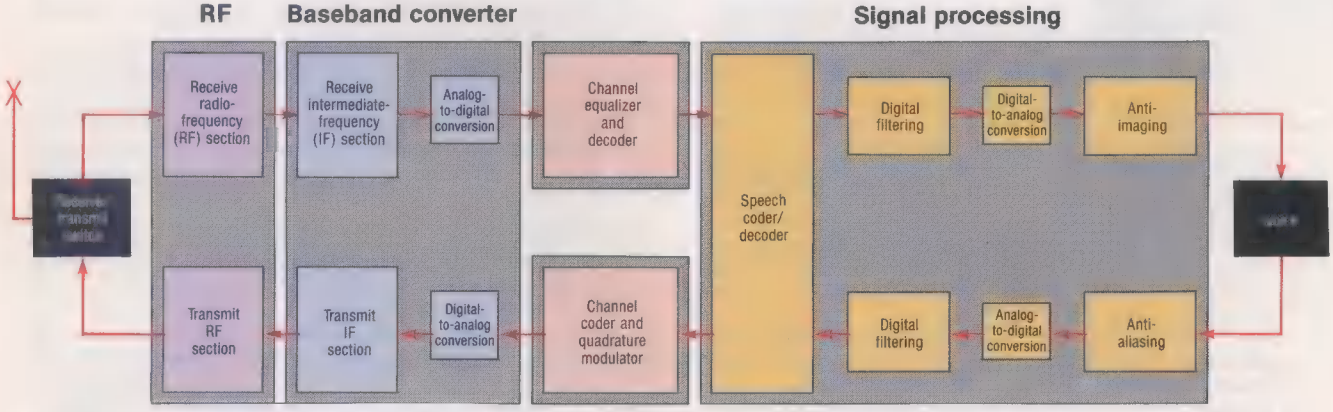
Analog Devices circumvented the problem by using oversampling for conversion, quantizing an analog signal with low resolution (1 bit) and a high sampling rate (2 MHz), then resampling this digital signal to obtain a new digital signal with 16-bit resolution at ■ kilohertz. The net effect of this strategy is to shift the need for precision from the analog circuitry of the converter to the digital circuitry of the DSP, which is far less sensitive to noise. "Oversampling is ■ 'brute force' method of conversion," said William Schweber, Analog Devices' senior technical marketing engineer. "Some might not consider it elegant—but it's effective." The company's ADSP-21msp50 is intended for digital mobile radio, where it can interface directly with speakers and microphones, other voiceband signal processing, and active noise cancellation.

Although demand for neural networks has grown little, many neural network systems are in development, and the potential is enormous for applications in real-time speech, character, and pattern recognition in general. Intel's electrically trainable analog neural network chip should advance such applications, with its 2-billion-connection-per-second speed. The chip contains 64 analog neurons and 10 240 synapses; ■ more advanced version, with an on-chip learning algorithm, will be introduced in March.

Mark Holler, Intel's neural network program manager, foresees major increases in density; neural networks will follow the same scaling trend as digital circuits, but, in addition, the cells per chip will take a large, one-shot jump when chip designers reduce the number of transistors per cell from 12 to as few as two. This will yield a one-time increase in cell density of three to five times, Holler said.

Adaptive Solutions Inc., Beaverton, Ore., favors a digital approach to neural networks. Digital neural chips can be more easily integrated into digital microprocessor–based systems, without extensive interfacing logic. On-chip learning algorithms train Adaptive Solutions' chips in seconds instead of the hours usually required with external training hardware. The company reports ■ processing speed of 1.6 billion connections per second with 8- or 16-bit weights assigned to neurons and 12.8 billion connections with 1-bit weights.

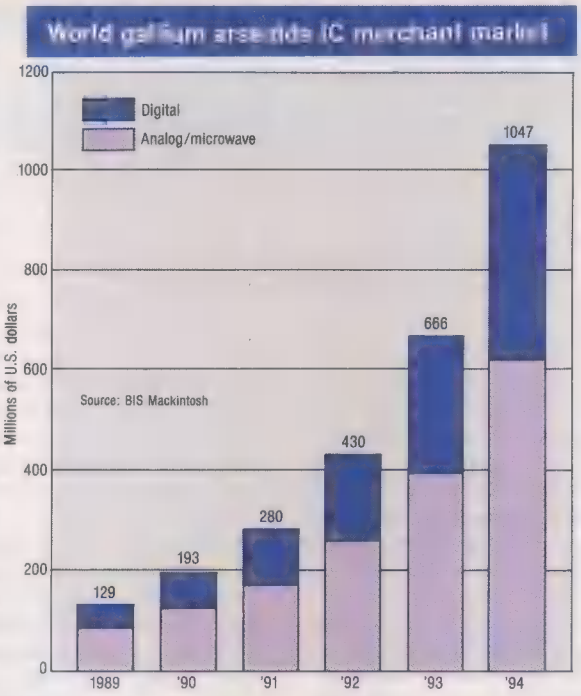
This year, sales of speedy gallium arsenide ICs are expected to surpass one-quarter of ■ billion dollars; by 1994, sales are expected to exceed $1 billion. Most of the growth will be in commercial high-speed computer and high-frequency communication applications, rather than in military ■■ in the past.



The design of an advanced digital signal processor, above, by Analog Devices Inc. for digital mobile radio, shifts the need for precision from the analog circuitry of the converter to the digital circuitry, which is far less sensitive to noise.

A key GaAs development was reported at December's International Electron Devices Meeting in San Francisco when researchers from Honeywell Inc., Bloomington, Minn., announced ■ 1000-bit RAM based on complementary GaAs field-effect transistors. The memory combines the speed of GaAs and the low power consumption ordinarily associated with silicon CMOS chips.

At the same meeting, researchers at IBM's Thomas J. Watson Research Center, Yorktown Heights, N.Y., showed that silicon can compete with GaAs as a material for ultrahigh-speed digital circuits. They operated silicon bipolar transistors at 76 gigahertz at room temperature and 94 GHz at 85 K—the fastest speed ever reported for a silicon three-terminal device, and twice as fast as the best results in silicon reported at the preceding year's meeting.



Thunderbird Technologies Inc., ■ start-up firm in Research Triangle Park, N.C., created ■ stir with its announcement of tests of digital silicon circuits at 398 MHz at room temperature, about four times the supposed limit for this technology. The chips were made on a standard CMOS production line. W. Andrew Grubbs, Thunderbird's president, said the company's engineers reviewed "the first principles of semiconductor theory and solved some hideous equations." They found that by tuning parts of the circuits independently and using unconventional circuit layouts, they can produce chips that have extremely high switching rates and need 70 percent fewer transistors. Thunderbird will "author" chips, Grubbs said, producing design tapes for use by third-party manufacturing facilities. He hopes to have a product—perhaps an SRAM for workstations—within two years.

Alliances, easy and uneasy

The year 1990 was one of associations of convenience, some of which ended unhappily. Negotiations between IBM and Motorola to license IBM's 4M-bit DRAMs, never acknowledged by the participants, collapsed in October, according to press reports. Instead, Motorola will use Toshiba's technology to make them. (It already makes 1M-bit SRAMs under license from the Japanese company.) Motorola did agree, however, to participate in R&D on IBM's synchrotron X-ray lithography.

IBM also threw in its lot with Munich's Siemens AG to jointly develop 64M-bit DRAMs. Joint activities are proceeding at IBM's Advanced Technology Center in East Fishkill, N.Y.; later work will use the production resources of both partners, who share costs equally.

Micron Technology Inc., Boise, Idaho, was licensed to use IBM DRAM technology. IBM, which manufactures ICs for its own use only, provided Micron with process technology and chip design for its 4M-bit DRAM. Micron has long been a chip supplier to IBM and may now produce and sell the 4M-bit devices to IBM and to other companies as well.

In Europe, an alliance of Philips NV of the Netherlands, Siemens AG of Germany, and the Italian-French SGS-Thomson Microelectronics BV faltered when Philips withdrew much of its support, citing economic difficulties. The alliance was already in pilot production of 1M-bit SRAMs and was working on larger chips.

A legal feud between Motorola and Hitachi over patent infringements approached ■ positive resolution when the companies agreed to negotiate their differences. A court-imposed ban on shipments of Motorola's 68030 microprocessor to customers was thus avoided.

In ■ transpacific agreement, AT&T Microelectronics and NEC Electronics, Japan's largest chip producer, announced they will exchange technology and designs and cooperate in manufacturing. The companies will cross-license application-specific IC fabrication and computer-aided design methods for an initial period of five years.

Sematech Inc., the Austin, Texas, consortium of 14 U.S. semiconductor manufacturers, continues its development of equipment, materials, and processes for future IC generations to be shared by its sponsors. Sematech suffered a serious setback in the untimely death of its president and chief executive officer Robert Noyce, a pioneer in integrated circuits. William J. Spencer, formerly group vice president of corporate research at Xerox Corp.'s headquarters in Stamford, Conn., was named to replace him.

New life for photolithography

Lithographic techniques made major advances. Commercial electron-beam lithography machines were introduced. Lepton Inc., Murray Hill, N.J., announced its EBES4, which can write up to five 8-inch wafers per hour with feature sizes smaller than 0.4 micrometer. The machine uses standard optical steppers.

Perkin-Elmer Corp., Norwalk, Conn., sold its prestigious Electron Beam Technology Division to ■ group of employees with equity participation from several large U.S. companies. The Hayward, Calif., company offers Perkin-Elmer's machines ■■ well ■■ IBM-developed electron-beam technology.

X-ray lithography is in a state of ferment. Japanese developers favor large synchrotron-based systems, while many U.S. researchers tend to believe that smaller laser-pumped sources are best for them. IBM has contracted with Hampshire Instruments Inc., Rochester, N.Y., for a demonstration of soft X-ray photolithography for 0.5-micrometer-feature circuits. Hampshire will manufacture X-ray masks, expose test wafers with a laser-based source, and provide test results.

Meanwhile, there seems to be surprising life left in photolithography. Canon U.S.A. Inc., Lake Success, N.Y., will make available this spring an i-line (ultraviolet) stepper for 16M-bit DRAM production. Using i-line photolithography and phase-shifting masks, Fujitsu succeeded in fabricating an experimental 64M-bit DRAM.

Another untraviolet system, Micrascan, jointly developed at a cost of over $100 million by IBM and Perkin-Elmer, is further evidence of the resurgence of optical photolithography. Micrascan uses ■ laser to generate deep ultraviolet rays and an innovative lens system to write patterns at high speed. Perkin-Elmer, which plans to concentrate on its instrument products, spun off Micrascan and other lithographic equipment lines to IBM and the Silicon Valley Group (SVG), a San Jose–based supplier of semiconductor production equipment. Sematech has promised support for the joint spinoff, SVG Photolithography Systems Inc.

Many proponents believe that photolithography will even be able to form the superfine (0.3 μm and less) patterns needed in 256M-bit memories. Then, when the world is ready for 1G-bit chips, X-ray and electron-beam lithography would come to the fore. ◆

TEST AND MEASUREMENT



Design-for-testability products in vogue
Communications testing diversifies
Artificial intelligence in a tester
VXI blossoms

Boundary scan, a method for designing testability into microelectronics and printed-circuit boards, came to market in 1990 in an array of products ranging from application-specific ICs (ASICs) to logic analyzers.

Furthermore, the quickly changing field of communications testing was marked last year by the bid of a new analysis technique, modulation domain analysis, for mainstream applications inside and outside communications, including disk-drive testing. And the adoption a few years ago of a standard for the VXI (VME extensions for instrumentation) modular instrumentation bus is finally bearing fruit in a cornucopia of new products.

The explosion of boundary-scan products was set off by the approval of a standard implementation of the method by the IEEE and the New York City–based American National Standards Institute (ANSI/IEEE Std 1149.1) last year. The standard is based on a proposal developed by the Joint Test Action Group (JTAG), an international collaboration of electronics companies initiated by Philips NV, Eindhoven, the Netherlands.

Boundary scan is increasingly viewed as imperative by systems companies, which have been seeking reliable ways of testing highly complex, miniaturized pc boards. Surface-mounted pc boards that contain state-of-the-art ICs such as microprocessors and high–pin-count ASICs cause particular test problems because interior test points on the board are difficult to probe. Boundary scan eliminates the need for probing; features built into ICs access the test points "electronically." Scan cells on the ICs feed logic states serially in and out during testing.

Most ASIC vendors now include boundary-scan cells in their libraries of standard cells—the circuits they offer for building ASICs. Some, such as Motorola Inc., Schaumburg, Ill., have begun to build boundary-scan circuitry into every ASIC. AT&T Co. and others also offer built-in-self-test (BIST) cells that operate in conjunction with boundary scan, allowing circuitry within ICs to be tested after they are mounted on a pc board.

Boundary scan is also being built into off-the-shelf "catalog" ICs. Texas Instruments Inc., Dallas, announced several products in 1989, including a range of 8-bit octal devices, such as buffers and latches, that can be used to partition a board into testable units. Also available are scan path selectors and linkers that connect octals and other boundary-scan devices as desired to test only portions of a circuit for quicker access. In 1990, the company announced two digital signal-processing (DSP) chips, the 320C51 and 320C40, that not only contain boundary-scan features, but also allow use of the serial access paths during the emulation process used to debug processor code. Also announced in 1990 was a digital bus monitor chip that can gather data during normal operation of the pc board at the system's clock speed, as opposed to serial off-line testing.

The Motorola 68040 microprocessor, introduced last year, was the first general-purpose processor to conform fully to the new boundary-scan standard, but the MIPS R4000 from MIPs Computer Systems Inc., Sunnyvale, Calif., and the 80486 from Intel Corp., Santa Clara, Calif., are rumored to follow suit.

Vendors of IC testers, now experiencing sluggish sales, are capitalizing on the boundary-scan boom by offering scan-testing software add-ons for existing products. Board test vendors—including GenRad Inc., Concord, Mass.; Teradyne Inc., Boston; and Hewlett-Packard Co., Palo Alto, Calif.—are also offering boundary-scan options for their products. In contrast, Motorola and Schlumberger Ltd., Paris, France, have jointly developed a tester called Typhoon specifically for scan testing of ICs, and Brothers Electronics Inc., Sunnyvale, Calif., has developed a tester for boundary-scan PC boards.

The arrival of the boundary-scan standard has led to a new class of tester, based on the personal computer. TI and Alpine Image Systems, Los Altos, Calif., have developed plug-in boards that allow IBM-compatible PCs to be used for boundary-scan testing. According to Pete Fleming, TI's technical program manager for corporate testability, these low-cost testers are more flexible than the products offered by automatic test equipment (ATE) manufacturers since they can be used on the lab bench and in the field. Similar low-cost testers can be built by systems companies themselves using test bus master ICs offered by AT&T and TI that convert between standard microprocessor buses and the serial boundary-scan protocol.

Karen Fitzgerald Associate Editor

INSTRUMENTATION FOR NONSCIENTISTS



RICHARD D. THORNTON: EXPERT OPINION

'There must be a reduction of complexity so that users . . . can cope with design, installation, operation, and maintenance of the system.'

Instrumentation designers are highly creative in employing the latest semiconductor device technology to construct ever more accurate, sensitive, and complex instruments. Designs based on the new VXI bus and the latest quantum-effect standards will change the way sophisticated systems are developed and used. But like the mainframe computer, these systems are expensive and designed to be operated by highly trained professionals. However important, they do not represent the main growth potential or problem areas for the instrumentation industry. The future belongs to instrumentation systems for nonscientists.

An instrument system integrates sensors, data processing, communication, controls, and user interfaces. It employs distributed sensors with local display and control, but requires centralized data processing for overall control of entire processes. The goal is lower cost, improved performance, and reduced complexity of each system component, but increasing complexity of the complete system and its intended function.

The following complex instrumentation systems are either in operation or planned; each involves over 100 instrumentation components, a central computer, and customized software:

- A water-purification control system, with sensors and displays scattered over a large area, controlling a multitude of pumps,

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The first small instrument to incorporate boundary scan in its circuitry is the Philips PM 3580 logic analyzer. According to Philips and John Fluke Manufacturing Co., Everett, Wash. (which sell each other's products in a global alliance), the addition has reduced service time. The boundary-scan circuitry and interconnections can be tested, as well as the functional circuitry.

Researchers at many companies and universities are developing new ways of using the standardized test features. A three-year project supported by the Commission of the European Community (CEC) was begun last year to develop new ASIC products, testers, design automation and test generation tools, and algorithms for fault diagnosis.

The project, involving staff from nine European companies led by Philips, will culminate in a demonstration of how these products can be efficiently linked.

HIGHLIGHTS

Success: Boundary-scan test method was formally adopted as a standard by the IEEE and the American National Standards Institute.
Shortfall: Automatic test equipment manufacturers failed to revive the market for their large production IC testers.
Notable: Hewlett-Packard Co. introduced new modulation-domain analyzer, predicting it will become as common as oscilloscope.
Newsmaker: VXIbus finally arrived amid an explosion of product introductions.

Hard times for ATE

ATE vendors are trying other strategies to rejuvenate their markets. Some are integrating many functions in one tester and others are making systems smaller and cheaper. Teradyne and HP introduced modular IC testers, Teradyne's 200-megahertz J971 system and the 400-MHz HP 82000, in which the customer can choose only the functions needed to keep costs down. Sienna Technologies Inc., Eagan, Minn., is concentrating on offering unique testing capability, such as electromigration, in its ITS8000 station.

The high costs of gallium arsenide microwave and millimeter-wave ICs (MMICs), whose development the U.S. Department of Defense is funding through its Mimic program, has shifted the focus of testing from the completed package to the wafer level in order to catch problems as early as possible. One of the roadblocks has been making a wafer probe that can handle frequencies as high as 100 gigahertz. Cascade Microtech Inc., Beaverton, Ore., moved closer to that goal this past October with the introduction of a 75-GHz probe.

The cost of testing itself is a large contributor to device cost; a few years ago, it contributed as much as 80 percent, according to Gary Roberts, HP's MMIC marketing manager. But faster and more efficient testing has brought it down to between 40–60 percent today, he said.

Time and frequency

A new technique for communications measurements made a bid for mainstream applications last year with the introduction of the HP 53310A modulation-domain analyzer. The instrument gives a real-time display of frequency vs. time—a hybrid of the oscilloscope's amplitude vs. time display and the spectrum analyzer's amplitude vs. frequency display. It can also display time intervals vs. time. A higher-performance modulation-domain analyzer, the HP 5371, was introduced in 1988, but its US $30 000 cost was out of reach for most applications. HP is counting on the $9500 price tag of the new instrument to make modulation-domain analyzers as common as oscilloscopes.

The HP 53310A, lacking the higher frequency range and computational sophistication of the HP 5371, boasts the advantage of real-time display (20 updates per second) since it need not store data for complex computations. HP's R&D project manager for the 53310A, Perry Jeung, told *IEEE Spectrum* that customers have been finding new applications for the technique since its introduction. It is particularly suited to analyzing signals that are modulated in frequency, such as frequency-agile, phase-locked

valves, and alarms.
- The nerve center of a large racing sailboat with sensors and displays throughout the boat and a computer providing steering, navigation, and performance-enhancing advice.
- An electric-utility monitoring system using remote sensors and sophisticated signal processing to identify potential failures in transformers, circuit breakers, pumps, and valves.
- A magnetic levitation system using distributed sensors and controls for automated guideway monitoring and remote alignment adjustment.

A key problem in all these systems is the interconnection of and communication between instrument hardware and software from a variety of manufacturers. There must be a reduction of complexity so that users who are intelligent but not instrumentation gurus can cope with design, installation, operation, and maintenance of the system. This implies a variety of standards, some by committee and some de facto.

IEEE standards seem destined to play an important role. Although most instruments today still use 4–20 mA, EIA-232, or IEEE 488 communication, the trend is to high-speed twisted-pair, coaxial, or optical-fiber cables—or even no cables at all! While some within the industry debate digital standards to replace 4–20 mA, such as the Fieldbus, most manufacturers have already adopted computer communication standards such as Ethernet, Cheapernet, or Token Ring. These IEEE 802.x. systems are supported by ICs from a variety of manufacturers, and hardware for Cheapernet costs the same as for the vastly inferior 4–20 mA.

In light of the importance to the instrumentation industry of communications standards that do not originate with it, I would pick the most important instrumentation development of the last year as the totality of new ideas for communications, some of which will certainly play a major role in future instrumentation systems. It is impossible to predict the winners, but here is an incomplete list of candidates:

- 10Base-T, the new IEEE standard for high-speed data transfer over twisted-pair wires.
- LAWN, local-area wireless network, from O'Neill Communications Inc., Princeton, N.J.
- Ardis, advanced radio data information service, a Motorola- and IBM-originated cellular-radio data network.
- Apple's Data Personal Communications using the 1.7–2.3-gigahertz band.
- A new consumer electronics system using power-line wiring for data exchange.
- FDDI (Fiber Distributed Data Interface) for very high bandwidths.
- Radio cellular telephone systems based on code division multiplexing.
- Wireless in-building network (WIN), Motorola Inc.'s new 18–19-GHz microwave system.

The challenges these new technologies and standards face are difficult: can instrumentation systems emulate the user-friendliness of the Macintosh with simple menus and common conventions between various manufacturers' hardware and software? Can standards encourage creativity as well as allow users to install, operate, and maintain instrument systems with little or no reference to a manual and to service them by modem and facsimile machines? Can instrumentation designers use established modem communication technology?

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A representative sampling of products conforming to ANSI/IEEE Std 1149.1

Product	Manufacturer	Function/features	Price
Available products[a]			
68040 processor	Motorola Inc.	Microprocessor	US $595[b]
SN74BCT8244/8245 SN74BCT8373/8374 Scope octals	Texas Instruments Inc.	Octal buffers and storage devices with testability	$4[b]
PM 3580/3585 logic analyzer	Fluke/Philips	Scan circuitry is testable, too	$4250–$10 950
proTEST-PC	Alpine Image Systems Inc.	PC plug-in tester for boundary-scan ICs	$3000
XLScan	Integrated Measurement Systems Inc.	Scan test option for prototype IC test system	$33 000 per module
Announced products			
WE DSP16C	AT&T Co.	Digital signal processor	$45
TMS 320C40/C51	TI	Digital signal processor	TBD
ACT8997/8999 scan path selectors	TI	Allows access to one of several scan paths on board	TBD
Typhoon IC tester	Motorola-Schlumberger	Designed for scan testing	$1.5–$2 million
ACT8990 bus controller	TI	Interfaces microprocessor bus to boundary-scan circuitry	TBD
ACT8994 digital bus monitor	TI	Logic analyzer on a chip	TBD
Asset tester system	TI	PC-based tester for boundary-scan ICs, boards, and systems	$25 000
Tapdance	AT&T	Generates conformance tests for boundary-scan ICs	$5000
BST800	Brothers Electronics Inc.	Boundary-scan tester for boards	$100 000

a Just about all ASIC vendors include boundary-scan cells in their library of standard cells, but are too [illegible] here.
b Price for 1000 pieces. TBD = To be determined.

loop, and signals found in voltage-controlled oscillators, air-traffic control, and cellular telephone applications. But it can also be used in communications and disk drive applications to measure the unintended modulation (jitter) on signals; it can display jitter vs. time directly.

The analyzer also can shed light on vibration problems in mechanical systems by measuring frequency variations in a transducer output over time. A recently discovered application is to characterize the rotating polygon mirror in laser printers.

Tektronix' approach to analyzing frequency-hopping signals and others that change quickly in frequency is real-time spectrum analysis, first made available in 1989 in the 3052 digital-signal processing system. Conventional fast Fourier transform (FFT) technology for translating signals into the frequency domain usually allows measurements to be taken no faster than every 20 milliseconds. Thanks to a uniquely designed bank of parallel filters and parallel processing features, the 3052 can make measurements 100 times as quickly, translating to a real-time bandwidth of 10 MHz (the instrument can measure modulation and carrier frequencies up to 325 GHz using block downconverters). Consequently, the instrument can characterize intermittent or elusive low-power signals, frequency-hopping transmitters, and data channels during bit error conditions.

With a $99 500 price tag, the 3052 is considerably more expensive than the HP 53310A modulation domain analyzer. But according to Tektronix marketing manager Douglas Goodman, the 3052 is much more adept at measuring signals in noisy environments than the 53310A, which is better suited for the "clean" signals found in production or disk-drive testing. Furthermore, Goodman said, the 3052 has the advantage of characterizing a signal in three dimensions—amplitude, frequency, and time—rather than the two dimensions offered by the HP 53310A, and so is better at measuring elusive spectral events.

A more specialized testing problem is engendered by the digital cellular radio system that is planned for implementation across Europe next year by the European Economic Community's Groupe Spéciale Mobile (GSM). It operates with a time-division multiple access (TDMA) signal that has been difficult to measure with spectrum analyzers and which would not succumb to a modulation domain analyzer either. Last year, HP developed time-gated spectrum analysis to handle these signals.

Designed to increase the capacity of mobile-radio bandwidths, the TDMA method uses multiplexing to allow several users to transmit simultaneously at the same frequency. Each TDMA frame contains pieces of data from eight or fewer separate transmissions, but since they are all at the same frequency, most spectrum analyzers cannot sort them.

When equipped with the proper options, the HP 8590 family of portable spectrum analyzers can operate using a time-gate circuit board that can turn measurement on and off so as to display only the data segment of interest. Software introduced last year makes it much easier to specify the control of the time gate. Called a personality card, this credit-card–sized package downloads software into the analyzer to transform it into a dedicated GSM tester.

Smart testers

Networks of computer-controlled instrumentation ["Instrumentation for nonscientists," p. 56] can provide an added benefit, especially for complex IC testing. Information and simulations generated during the design stage can be fed directly into the manufacturing environment to generate test programs automatically. For example, Giordano Associates, Pine Brook, N.J., is peddling a product called Smart (smart, mobile, and reconfigurable tester) that uses knowledge-based automatic diagnostics to test systems, boards, and digital and analog components.

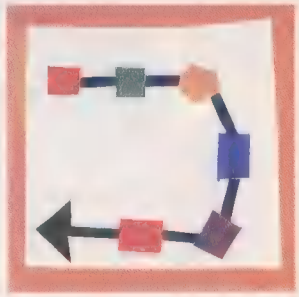
Using simulation data from a computer-aided engineering workstation, Smart conducts a testability analysis, generating a matrix of potential symptoms and faults that can be updated as more information is learned. Then a test program is developed with the help of the user and run on a 25-MHz tester. Packaged in either a PC-based system, the PC 2000, or a VXI-based system, the VXI 2000, Smart comes in at under $50 000.

The VXI standard, an instrumentation bus for modular instruments that can be mixed and matched for plug-in to a VXI chassis, finally broke through in a wealth of products last year. Since the standard was established in 1987, manufacturers have been slow to take it up for a number of reasons, one of which was customer concern about higher cost.

The first products introduced after the standard was implemented were the chassis and then embedded controllers. Four different sizes of chassis (A through D from smallest to largest) are included in the standard. However, most products are gravitating to the C and B sizes (B is comparable to portable or benchtop instruments). A B-size embedded controller was introduced last year by RadiSys Corp., Beaverton, Ore., and a C-size controller, compatible with IBM PC AT and Macintosh computers, became available from National Instruments Corp., Austin, Texas.

Racal-Dana Instruments Inc., Irvine, Calif., introduced a time-interval analyzer and an RF chassis, and HP added a B-size 500-MHz oscilloscope to its line of VXI multimeters, counters, timers, digital-to-analog converters, and relay multiplexers.

INDUSTRIAL ELECTRONICS



Clear future for fuzzy logic
MAP and CIM advance
CNC takes to RISC
X-ray laminography resolves 25 micrometers

Fuzzy logic, intelligent control, and computer-integrated manufacturing (CIM) are hot topics in industry, and for good reason—all are seen as improving manufacturing flexibility and reducing costs. At the same time, advanced computer numerical control (CNC) based on a reduced-instruction-set computer (RISC) chip is expected to sharpen precision in high-speed machining. There are also notable advances towards an open system architecture for programmable controllers and machine vision systems and in X-ray laminography systems for inspecting the solder joints on printed-circuit boards, particularly those of surface-mounted components.

Many in the manufacturing and process industries believe that fuzzy logic control has a bright future in systems that have many inputs or are highly nonlinear and hard to model. (Unlike the rigid yes-no logic of present control systems, fuzzy logic is based on probabilistic human reasoning; it weights each statement with a variable chance of proving true or false—say, 80/20 or 50/50—whereas yes-no logic in effect assigns them all a uniform 100/0 chance.) Today fuzzy logic control seems all set to invade the manufacturing equipment market, following its early victories in consumer electronics in Japan.

Fuzzy logic controls

One application involves a system for plasma-etching metal surfaces to prepare molds for injection molding. Masaki Togai, chairman and chief executive officer of Togai InfraLogic Inc., Irvine, Calif., told *IEEE Spectrum* in November that a fuzzy logic controller recently developed for this system produced the mold in 35 minutes, instead of 51. To eliminate carbon buildup on the workpiece, the system monitors three parameters: the temperature of oil in which the workpiece is immersed, the voltage between the cathode and the workpiece, and the current flowing between the two (both indicate the size of the gap between workpiece and cathode). Then the system adjusts the gap in the light of expert information included in the memory of the fuzzy logic controller.

Elsewhere, researchers with General Electric Co.'s Research and Development Center in Schenectady, N.Y., demonstrated an intelligent controller for gallium arsenide crystal growth. Developed under a grant from the U.S. Defense Advanced Research Projects Agency, Arlington, Va., the Meta Controller executes "plans," or English-language scripts that an operator follows during crystal growth. Typically a plan may contain such elements as initial and final conditions, sequence of actions, and a recovery action to be taken should the plan fail.

A third controller based on fuzzy logic directs the spray forming of hard metal alloys (combining nickel, chromium, iron, and molybdenum) at the Metals and Welding Division of the David Taylor Research Center at the U.S. Navy's facility in Annapolis, Md. In the spray forming process, the controller manipulates such parameters as surface roughness, rate of alloy deposition, surface temperature, and metal flow rates.

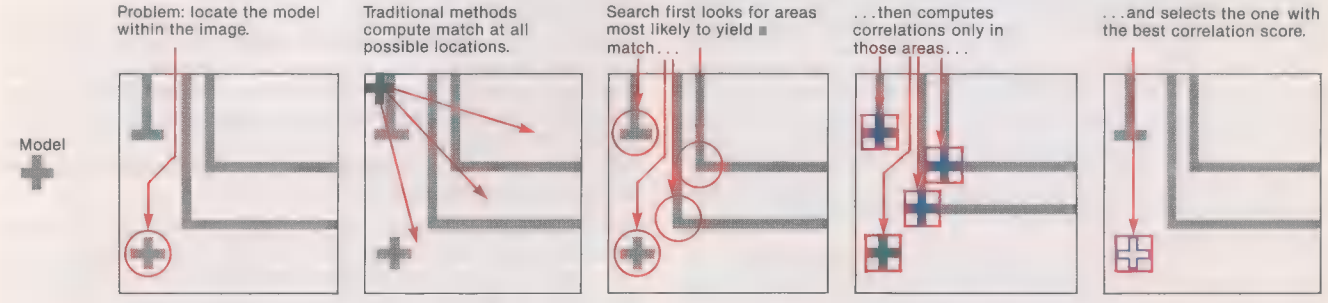
The use of fuzzy logic for this controller is absolutely vital because a strict mathematical modeling of the system is "suicidal—very hard to deal with," *IEEE Spectrum* learned in November from Alexander Meystel, a professor of electrical and computer engineering at Philadelphia's Drexel University. Meystel is expert in this area and chaired the Fifth IEEE International Symposium on Intelligent Control last Sept. 5–7 at Drexel.

Other recent fuzzy logic applications include a controller of an aircraft's roll and structural torsion moments developed at Rockwell International Corp.'s Science Center, in Thousand Oaks, Calif.; elevator controls by Otis Elevator Co., Farmington, Conn.; and supervision of controllers at the Instituto Superior Tecnico, in Lisbon, Portugal. Also, Germany's Siemens AG has formed a 10-person task force on fuzzy controls as part of its new research group on Intelligent Control Systems in the company's central laboratories in Munich.

CIM in focus

Of concern these days to governments as well as manufacturing plant managers and engineers is computer-integrated manufacturing (CIM). Germany's Federal Ministry of Research and Technology alone has appropriated about $250 million for 1988–92 to support innovation in manufacturing, with emphasis on CIM for smaller companies. Systec 90, an international

Gadi Kaplan Senior Technical Editor



In pinpointing a desired object (model) within an image by means of a correlation-search algorithm, the Cognex 4000 Series machine vision system from Cognex Corp. first looks at those areas most likely to yield a match. It then computes correlations with the object only in those areas, rather than throughout the image, subsequently computing the best correlation score.

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trade fair for CIM held in Munich last Oct. 22–26, included a demonstration of the Manufacturing Automation Protocol (MAP) and the related Technical and Office Protocol by a group of 25 firms from seven countries, all members of the European MAP User Group.

Recognized as a world standard, MAP version 3.0 is now practiced worldwide. More than 40 companies supply products that conform to that version, and the first installations based on this equipment are already in production.

The Munich fair included several exhibits related to machine tools from the technical universities of Aachen and Munich, among others.

RISC-based CNC

GE Fanuc recently announced its Series 16 CNC system, the world's first such system to include a RISC microprocessor. Because it can carry out repetitive intensive computations at record speed, this 32-bit RISC microprocessor lends much more precision to high-speed machining than earlier CNC generations could. Other novel features of the system include very tight packaging and an advanced thin-film–transistor, liquid-crystal display with enhanced contrast.

More flexibility in industrial automation is offered in another GE Fanuc family of programmable controllers. The Series 90-70, for up to 12 000 inputs and outputs, was introduced in November 1989, and the Series 90-30, for up to 512 inputs and outputs, was announced last April. Said to be the first programmable controller to be based on the widely accepted VMEbus standard, the Series 90-70 offers users an open architecture—users may add on to the controllers any boards compatible with the VMEbus. Before, a user was tied to his vendor's proprietary products for add-ons.

Another programmable logic controller advance is Simatic S5-155U, a machine with high processing power available since last February from Siemens Energy & Automation Inc., Roswell, Ga. Siemens calls it "the most powerful PLC in the marketplace today," and it can certainly operate up to four central processing units simultaneously, ensuring a high level of parallel processing, among other attractive features.

HIGHLIGHTS

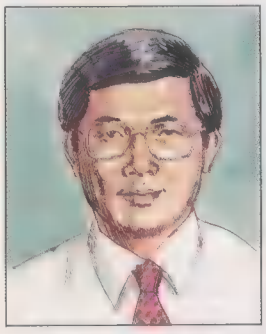
Success: An X-ray laminography system, 3DX Series 2000, became popular for surface-mounted pc-board inspection among such major manufacturers as IBM, Boeing, and Siemens.
Shortfall: Such leading U.S. robot manufacturers as Unimation, General Electric, United Technologies, IBM, and Cincinnati Milacron discontinued their robot businesses, yielding a major part of the market to Japanese manufacturers.
Notable: Representatives of Japan's Ministry of International Trade and Industry and the U.S. Department of Commerce agreed on May 9, 1990, on a cooperative plan, effective through Dec. 1991, to revitalize the ailing U.S. machine-tool industry.
Newsmaker: Lofti A. Zadeh, professor of electrical engineering and computer science at the University of California, Berkeley, received the 10-million-yen Honda Prize of 1989 on Nov. 17, 1989, in recognition of his "great achievement in establishing Fuzzy Theory with the possibility of developing into extensive applications."

A crucial, albeit often weak, link in electronics manufacturing quality has been the visual inspection of printed-circuit boards before and after soldering. The situation has been exacerbated by the increasing use of surface-mounting technology for really densely packed boards. The 3DX Series 2000 X-ray laminography system from Four Pi Systems, San Diego, Calif., has proved popular among such leading manufacturers as IBM, Siemens, and Boeing, to name a few. Encouraged by this, Four Pi has developed a new model—3DX Series 3000—with a variable field of view (zoom in and out, as compared to the fixed focus of the Series 2000) and with vastly improved resolution and throughput. The new model resolves a defect as small as 1 mil (25 micrometers), vs. the 2 mils of its predecessor, and doubles throughput. It will be available next month.

In computer-based vision systems that look at the surface of such objects as pc boards for alignment, identification, and other purposes, the Needham, Mass., company of Cognex Corp. has more than 60 percent of the world market. Last October it introduced the Cognex 4000, which offers what the manufacturer called real-time image processing plus—for possibly the first time in the industry—compatibility with the VMEbus. Key to the fast processing is an efficient correlation-searching algorithm evolved from earlier systems [see illustration, p.59].

Other machine vision developments include two developmental systems with pipelined architecture—one devised by researchers from the Korea Advanced Institute of Science and Technology, the Korean Institute for Science and Technology, and Samsung Aerospace Industries Co., all in Seoul, Korea, and the other by researchers with Hitachi Ltd.'s Kanagawa Works. Both were reported at Iecon '90, the 16th Annual Conference of the IEEE's Industrial Electronics Society, held last November in Pacific Grove, Calif. ◆

SYSTEMS INTEGRATION A BURNING ISSUE



REN C. LUO: EXPERT OPINION

'Perhaps the most important development has been the growth in the creation of microsensors, micro-actuators, and micromachines.'

Systems integration, especially in manufacturing automation, is the burning issue in industrial electronics. In a good integrated system, the interfaces function smoothly, passing information quickly and accurately from one subsystem to another to make the concept of "just-in-time" a reality.

System integration can be formulated hierarchically into three levels: sensor and signal integration on the lowest, manufacturing-cell integration on the next, and factory automation at the highest level.

The concepts of systems integration and concurrent product and process design can be applied to rapid prototyping of, for example, custom orthopedic footwear. In a recently developed system, a three-dimensional laser range-finder links up with digitization capabilities to record the complex shape of a patient's foot and store the data in a computer for analysis. An interactive graphics package then visually displays the data acquired to allow the user to transform it into a shoe last. An interface translates this data into machine code for downloading to a computer numerically controlled (CNC) machine, which fabricates the last. An automatic verification program checks the fabricated last against the desired last.

Some companies have already implemented a similar concept using 2 1/2-D digitization technology (2-D plus depth). They include Robotic Vision Systems Inc., Hauppage, N.Y.; Laser Design!, San Francisco; Cyber Optics Corp., Minneapolis, Minn.; and Hymare Ltd. of Nepean, Ont., Canada.

But perhaps the most important development has been the growth in microsensors, micro-actuators, and micromachines. For example, silicon microsensors for low pressures (up to about 480 pascals) are in production at Lucas Novasensor, Fremont, Calif. An annual IEEE workshop in Micro Electro Mechanical Systems (MEMS), sponsored by the IEEE Robotics and Automation Society, fosters communication among MEMS researchers and users to further the growth of this field.

Ren C. Luo (SM) is a professor in the department of electrical and computer engineering and a director of the Robotics and Intelligent Systems Laboratory at North Carolina State University in Raleigh. His bachelor's and master's degrees are from Feng Chia University, Taiwan, R.O.C. (1973 and 1975, respectively) and his Diplom Ingenieur and Ph.D. from the Technical University, Berlin, Germany (1979 and 1982). He serves on the IEEE Industrial Electronics Society's Administrative Committee and is chairman of its Technical Committee for Robotics, Vision, and Sensors.

POWER AND ENERGY



Clean Air Act amended
Electric vehicles to the fore
Gulf crisis convulses oil markets
Privatization in the UK

Any lingering doubt that the world's electric power industries are driven primarily by politics was probably dispelled last year.

Global reverberations of the crisis in the Persian Gulf offered the most striking confirmation, causing wide fluctuations in oil prices and prompting utilities all over the world to reconsider energy technologies not taken seriously since the last oil crisis.

In Europe, major developments included the privatization of British electric utilities, the takeover of the antiquated East German power system by three West German utilities, and the Swedish Government's apparent retreat from a plan to abandon its nuclear power program.

In the United States, amendments to the Clean Air Act—the first in 13 years—will have expensive ramifications for that country's utilities. Another response to increasing pressure for cleaner air, not only in the United States but in Europe and Japan as well, was the resurrection of an idea whose time still may not have come: the electric vehicle. Last year, major automakers and other technical firms in all three regions pledged to commercialize electric cars in the near future.

Clean but costly air

Ratified late in October, the amendments to the Clean Air Act could cost industry US $22 billion over the next decade or so as provisions of the legislation are phased in, according to the Environmental Protection Agency in Washington, D.C. Utilities will be most affected by new regulations related to the control of acid rain; these regulations could cost $5–$7 billion over the next 15 years, according to estimates by the Edison Electric Institute (EEI), a Washington, D.C.–based trade group representing U.S. investor-owned utilities.

"Obviously this is a landmark piece of legislation," said Diane Smiroldo, an EEI spokesperson. "It's going to affect everybody who buys electricity, whether they're an industrial or residential customer."

The acid-rain controls require utilities to reduce, in two phases, their emissions of nitrogen oxides and sulfur oxides (NO_x and SO_2) by 10 million tons (9 million metric tons) from 1980 emission levels. The first phase of the program begins in 1995, and the second, at the turn of the century. In an interview, Smiroldo said EEI expects that some utilities will install smokestack "scrubbers" to reduce their SO_2 emissions, some will switch to fuels with lower sulfur content, and others will build plants around emerging clean-coal technologies, such as fluidized-bed and coal-gasification systems.

Since 1986, the Department of Energy, Washington, D.C., has supported commercialization of these technologies through a $2.5 billion program of Federal funds, which are shared 50–50 with industry. Currently, however, U.S. industry is contributing roughly two-thirds of the cost of the projects, so the value of the total technology development program may grow to more than $6 billion, according to C. Lowell Miller, associate deputy assistant Secretary, clean-coal technology.

One of the more intriguing possibilities posed by the Clean Air amendments is an expansion of an existing emissions trading program, under which utilities get credits if they manage to reduce emissions below their allotments. These credits can then be sold or traded to other utilities. "It's an interesting concept," said Smiroldo. "We hope it works. The key will be how it's implemented."

A similar emissions-credit system was initiated nearly 14 years ago by the last round of Clean Air amendments, noted John Palmisano, president of Aer*x Inc., an environmental and economic consulting firm with offices in Washington, D.C., and Los Angeles. But with the more stringent regulations enacted with the latest amendments, Palmisano said, trading of credits could by August become a daily rather than weekly occurrence, as it is now. "More companies are now affected, and affected in a more rigorous way," Palmisano explained. "We'll have more clients needing more credits. If it's successful, it will be the template, I believe, for controlling greenhouse gases, except you'll have a worldwide marketing system for that."

Electric cars charge forward

Even before the Clean Air Act amendments were approved, mounting environmental pressures had prompted major announcements related to electric vehicles last year. In the United States, General Motors Corp., Detroit, Mich., stole the spotlight with its Impact [THE INSTITUTE, March 1990, p. 6]. The sleek two-seater uses lead-acid batteries to accelerate faster than some conventional sports cars. The 395-kilogram battery provides a range of just under 200 km between charges, and would last for less than 40 000 km, GM projects. Thus the battery would have to be replaced several times over the life of the vehicle, each time at a cost of at least $1500.

Last April, GM announced that it planned to make the Impact available commercially in the mid-1990s. Some industry observers, however, were skeptical of the claim, noting that such forecasts were made routinely in the 1970s and failed to prove accurate.

Top 10 U.S. utilities in kilowatthour sales

1989 rank	1988 rank	Company	Kilowatthour sales, in U.S. dollar billions (10^9)	Percent change in 1989
1	1	The Southern Co.*	136.9	+4.60
2	2	American Electric Power Co.*	117.5	+12.18
3	3	Texas Utilities Co.*	81.9	+1.51
4	4	Commonwealth Edison Co.	72.2	+0.93
5	6	SCEcorp*	69.1	+1.84
6	7	Duke Power Co.*	66.6	+0.65
7	8	FPL Group Inc.*	64.1	+7.10
8	5	Pacific Gas & Electric Co.	63.8	+2.19
9	11	Allegheny Power System Inc.*	59.1	+4.64
10	9	Middle South Utilities Inc.*	58.9	+1.37

Source: *Electric Light & Power*
* Holding companies

Glenn Zorpette Associate Editor

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Ford Motor Co., in Dearborn, Mich., and Chrysler Corp., in Highland Park, Mich., also have significant electric vehicle programs under way, and these efforts have for some time involved sodium-sulfur and nickel-iron batteries, which promise much better range and durability than the lead-acid technology. Ford has tested Canadian-made sodium-sulfur batteries in an experimental Aerostar van, and Chrysler has produced an electric version of its Dodge Caravan and Plymouth Voyager minivans, powered by nickel-iron batteries.

With a top speed of about 70 mph (112 km/h), this TEVan is said to get 120 miles (about 190 km) between charges. The second TEVan was delivered to Southern California Edison Co., Rosemead, Calif., in late October, according to Joseph Reeves, Research Manager at Edison. (The first TEVan went to the Electric Power Research Institute in Palo Alto, Calif., which is cosponsoring development of the vehicle with Edison. By 1992 there could be a dozen TEVans on the road, according to current projections.) This year, several North American utilities will take delivery of ■ "G-Van," powered by lead-acid batteries, now being manufactured by Vehma International Inc. in Markham, Ont., Canada.

Early in November, GM, Ford, and Chrysler agreed on the need to jointly develop advanced batteries suitable for powering electric vehicles. Representatives of the three companies met with officials of various electric-utility and electric-vehicle research organizations. Although specific battery technologies were not selected for further development at the meeting, two lithium cells and one sodium-sulfur battery were reportedly discussed. The costs of the program—which could be in excess of a billion dollars, the automakers estimated—would be split among the Department of Energy, U.S. utilities (through the Electric Power Research Institute), the automakers, and several battery manufacturers.

Interest in electric vehicles is also high among virtually all European automakers. Last June, Fiat Auto SpA in Turin, Italy, launched the Elettra; outfitted with lead-acid batteries and traveling at ■ constant 48 km/h, the vehicle gets up to 120 kilometers between charges (185 km with the optional nickel-cadmium batteries). Top speed is about 72 km/h. At $20 000, it costs twice as much as the Panda, the conventional automobile on which it is based.

In Heidelberg, Germany, Asea Brown Boveri Ltd.—one of the main developers of the sodium-sulfur battery—has tested its system in an assortment of electrified vehicles based on Volkswagen, Mercedes, and BMW bodies.

Nippon Steel Corp. in Tokyo, the leading electric vehicle developer in Japan, unveiled its Next Generation Advanced Vehicle (NAV) last year, claiming ■ range of 240 km between charges and a top speed of 110 km/h. Toyota Motor Corp., in Toyota City, the other leading light of the budding Japanese electric vehicle community, displayed a vehicle with ■ range of 160 km between charges and a top speed of 85 km/h. Toyota also announced an agreement with Chubu Electric Power Co. in Nagoya to develop three commercial electric vehicles.

Oil woes

While such vehicles offered the optimistic ■ glimpse of a future less dependent on fossil fuels, the Persian Gulf crisis countered with a powerful reminder of current realities. In early August, oil was selling for $17–$18 per barrel, a price that doubled within weeks after the crisis began.

As a group, Japanese electric utilities meet about ■ third of their demand with oil. Before the Gulf crisis, Tokyo Electric Power Co. (Tepco), the world's largest private electric power company, had relied on Iraq and Kuwait for about 3 percent of its oil and liquefied natural gas, according to Kiichi Suganuma, ■ company spokesman. Following the ban on trade with those countries, Tepco made up the difference by importing more fuel from other sources, including Indonesia, Malaysia, Brunei, Yemen, and China, Suganuma said.

"We're suffering from higher oil prices, of course, but there's nothing we can do about it," Suganuma told *IEEE Spectrum* in mid-November.

Demand-wise, the summer of 1990 in Japan was a replay of the summer of 1988 in the United States. By early August, high heat in Japan sent total demand soaring to no fewer than five record highs. For Tepco, ■ particularly close call came on July 19, when the utility, heavily assisted by its neighbors, barely met ■ record demand of 48.98 gigawatts. The increase in peak demand from the summer of 1989 was 6 GW—three times the usual annual increase, according to Suganuma. According to the most recent demand forecasts, Japanese utilities will need another 59.1 GW by 1999—14 GW more than they are currently planning on installing by that time.

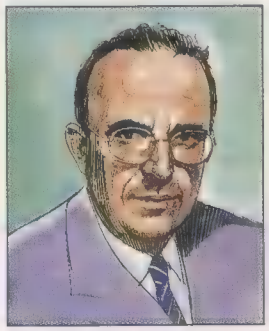
Only about 5 percent of electricity in the United States is produced by oil-fired generators, but the percentage is much higher in parts of the Northeast, where strict environmental regulations and strong opposition to nuclear plants rule out the use of most other fuels. When the Gulf crisis began, the Long Island Lighting Co. (Lilco) in Hicksville, N.Y., was using oil to generate almost two-thirds of its output, making it one of the most oil-dependent utilities in the United States. Within weeks, Lilco—perhaps best known for its inability to obtain a license for an 820-megawatt nuclear plant in the village of Shoreham, N.Y.—was scrambling to reduce its oil needs, according to spokesperson Karen Hellman.

Three plants, representing about 700 MW, were switched to natural gas and the company began purchasing electricity from outside sources whenever possible, Hellman said. All told, such measures allowed Lilco to cut its share of oil-fired generation to 42 percent for the month of September. Nonetheless, rate increases of just under 2 percent were instituted in August and September, in compliance with the utility's rate agreement with the state of New York. Typically, fuel accounts for 30 percent of a

HIGHLIGHTS

Success: Seabrook nuclear power station in New Hampshire went on-line.
Shortfall: Electrical fires and explosions rocked utilities in New York City, Chicago, and Pasadena, Calif.
Notable: British utilities began privatizing; U.S. firm built cogeneration plant at Teeside, in northeast England.
Newsmaker: General Motors Corp. chairman Roger Smith, who, shortly before retiring, pledged to make an electric vehicle commercially available within five years.

AWARENESS IS GROWING ABOUT THE DANGERS OF FOSSIL FUEL



HENRI PERSOZ: EXPERT OPINION

'For perhaps the first time in history, the possibility of war is exclusively linked to energy issues.'

The unfortunate consequences, both political and ecological, of excessive consumption of fossil fuels have become abundantly clear.

The world's political instability can be attributed, at least in part, to the fact that oil fields are most unevenly distributed throughout the globe. The world will never be at peace while wealth is transferred to a minority of countries that are able to accumulate it for arbitrary reasons.

This situation is, of course, best exemplified by the activity in the Persian Gulf. For perhaps the first time in history, the possibility of war is exclusively linked to energy issues.

Awareness is also growing about other dangers of long-term fossil-fuel consumption: air pollution and global warming. These problems should be an incentive for developed countries to reduce their consumption of fossil fuels substantially (the more so as such fuels should be earmarked for Third World countries

Lilco ratepayer's bill, Hellman said.

Not all utilities are lamenting the upsurge in oil prices. In England and Wales, prices for electricity are set in an open market, and at peak hours are based on the costs incurred with oil-fired peaking units—even though the bulk of the electricity is coal-fired. Thus higher oil prices mean higher profits.

UK utilities privatize

In December, the 12 regional electric companies (RECs) in England and Wales were converted to investor-owned companies through the sale of some $10 billion worth of shares. (The RECs are responsible for distribution only; another organization, the National Grid Co., transmits the electricity and is jointly owned by the 12.) Britain's power-generating companies, National Power and PowerGen Plc., both based in London, will follow suit beginning next month and are expected to fetch nearly $7 billion. ScottishPower and Hydro-Electric—responsible for generation, transmission, *and* distribution in Scotland—are to be floated on the London exchange in May or June, and may net a combined $3 billion.

To drum up interest in the sale, the London-based Dewe Rogerson communications group and the WCRS advertising agency found the ideal spokesman. Flat head and green skin notwithstanding, Frankenstein ("Frank" for short) tells Britons how and where to buy shares in a series of print and broadcast advertisements.

The utility conversion follows the privatization of such large UK concerns as Jaguar Plc., British Airways Plc., and Rolls Royce Plc., but is by far the most complex such endeavor, said Christopher Rowland, senior electricity analyst at Barclays de Zoete Wedd, the London-based investment bank.

Accompanying and greatly complicating the transition, Rowland said, were Britain's first steps toward fostering competition in electricity generation. In late summer, Enron Power Corp., a League City, Texas–based concern, announced that it would build and operate a 1725-MW gas-fired plant at Teeside, in northeast England. Under the terms of this unique international deal, 15 percent of the output will be bought by a nearby plant owned by Imperial Chemical Industries Plc., and the rest by four regional electricity companies.

Anticipating further opportunities opened up by competition, British utility executives have already begun considering an electricity futures market, in which utilities, generating companies, industrial customers, and traders would participate. British utilities are also now considering entering the telecommunications business by installing optical-fiber lines along their existing transmission routes.

Continental developments

The way was cleared late last August for another European privatization, of sorts, when Germany's Federal Cartel Office in Berlin approved the takeover of the state-owned electric utilities in eastern Germany by RWE AG (the largest western German utility) and two other firms. Under the agreement, RWE will take a 75 percent stake in the east German grid, with the remainder split between PreussenElektra AG in Hamburg and Bayernwerk AG in Munich. Shortly after the announcement, RWE chairman Friedhelm Gieske announced that the company would have to spend at least $3.3 billion refurbishing the eastern German electrical system.

In Sweden, meanwhile, public opinion has apparently turned against a movement to phase out the country's nuclear program by 2010. Twelve nuclear plants supply 45 percent of electrical demand, a proportion second only to that of France. Swedish consumption of electricity, per capita, lags only the United States, Norway, and Canada [see table, p. 64]. According to press reports, surveys in Sweden have indicated that 58 percent of the population favors continued operation of the nuclear plants, especially if they are important to Swedish competitiveness. Nonetheless, the country's Social Democrats vow to continue with a timetable to begin closing nuclear plants in the mid-1990s.

In Spain, a projected 7.5-GW shortfall by the year 2000 has also prompted a reconsideration of the country's decision to mothball five partially constructed nuclear plants, including an almost completed 2000-MW facility in Extremadura. Few expect the plants to go on-line, however, because of widespread political opposition.

Framatome, the sole maker of nuclear reactors in France, formally returned to state control last October. The majority stake in the company has bounced between CGE, the technical concern, and a shifting group of Federal agencies including the French atomic energy authority, CEA (all are Paris-based). In reacquiring the majority stake, French officials cited Framatome's strategic importance. Approximately three-quarters of France's

that are not—or should not be—in a position to avail themselves of nuclear power for many years to come).

Reducing dependence on fossil fuels will entail increasing use of nuclear power and renewable resources such as hydroelectric energy. Will developed countries be wise enough to return to investments in nuclear power? It is probably too soon to tell, but such a return remains an important challenge for the future.

Political turmoil is not limited to the Gulf region. In Europe, the changes have been both peaceful and exceedingly rapid. Germany is perhaps the most notable example: less than 11 months after the Berlin Wall fell, on Nov. 9, 1989, the country was reunified.

Such developments will have major ramifications for the transmission and distribution of electrical energy on the Continent. Whereas there have been very few electrical energy exchanges through the so-called Iron Curtain (10 to 30 times less, per kilometer of border, than across borders between Western countries), the future will certainly bring a substantial increase in these exchanges. Through such exchanges, utilities with adjacent service territories, separated only by an international border, will assist one another, and perhaps organize major power purchases.

In the past, the relatively small power exchanges between East and West were handled via back-to-back direct-current facilities, since the flows were so small in comparison with the capacity of the grids connected. With the anticipated increase in exchanges, however, alternating-current interconnections can be envisioned, indeed, desirable from an economic point of view. The European electrical-reliability groups involved will be the Union for the Coordination of Electricity Generation and Transmission in the West and the Council for Mutual Economic Assistance in the East. Links are also possible with the utilities in the Organization for Nordic Electrical Cooperation (Nordel).

The possibility of such developments poses a great number of questions and concerns. Will it be possible to synchronize a 350 000-megawatt grid? Can the grid's security be assured in the event of a serious incident in a country? How long will it take before Eastern European utilities have power-control systems conforming to Western standards? How large can electrical grids be? How should they be planned and managed? How should a major interconnection project be organized and executed?

Of course, these are questions of interest beyond the European continent. North America has for decades confronted the problems of operating large, interconnected grids. In fact, Committee 37 of the International Conference on Large, High-Voltage Electrical Systems is considering launching a major study of grids that encompass hundreds of thousands of megawatts.

Clearly, engineers specializing in electric power will be challenged to keep up with the startling pace of international developments. Increasingly, the successful engineer will be a well-informed one.

Henri Persoz (F) is general inspector for generation and transmission systems at Electricité de France. He is also chairman of the Large Systems and International Interconnections Study Committee of the International Union of Producers and Distributors of Electrical Energy.

The world's top 10 energy producers and what they consume

Country	Production 1989 monthly average, millions of kilowatthours	Consumption 1988 annual total, millions of kilowatthours	Consumption 1988 per capita, kilogram-oil equivalent[a]	Per capita rank
United States	231 554	2 566 198	7655	3
USSR	143 500	N.A.	N.A.	N.A.
Japan	62 811[b]	672 317	3306	22
China	49 549	N.A.	580	N.A.
Germany	46 631	386 324[c]	4421[c]	13[c]
Canada	42 716	423 541	9683	1
France	30 456[b]	309 640	3704	18
United Kingdom	25 933	274 396	3756	17
India	20 428	N.A.	211	N.A.
Italy	17 570	202 453	2608	27
South Africa	13 062[b]	N.A.	2439	28
Poland	12 124	N.A.	3453	20
Australia	11 696[b]	119 935	5157	9
Sweden	11 612	128 857	6617	4
Spain	11 328[b]	116 922	1902	34

Sources: United Nations Statistical Office; International Energy Agency; World Bank
a Refers to commercial forms of primary energy (electricity plus oil, natural gas, coal, etc.) converted into oil equivalents; for converting primary electricity (nuclear, geothermal, and hydroelectric power), a thermal efficiency of 34 percent was assumed.
b Figures are for 1988.
c Federal Republic only.
N.A. = Not available

electricity is derived from nuclear power.

The main French utility, Electricité de France (EDF), Paris, announced in July that it would supply its Spanish counterpart with up to 1 GW of electricity until the mid-1990s. Spain will pay about $4 billion for the electricity, which will help alleviate the country's anticipated shortages. France already exports electricity to Britain, Switzerland, and Italy; in 1989, these exports were worth about $1.64 billion.

Seabrook goes on-line

The U.S. nuclear industry, long-starved for encouraging news, could take heart from several unrelated developments: Seabrook Station, a contested 1150-MW nuclear plant on the New Hampshire coast near Massachusetts, finally went into full-power operation; the Environmental Protection Agency authorized the use of a nuclear waste repository near Carlsbad, N.M.; and Westinghouse Electric Corp., Pittsburgh, won a major grant from the Department of Energy to continue developing a relatively small, advanced light-water nuclear reactor.

After receiving a full-power license on March 15, Seabrook reached its rated capacity on Aug. 19, according to Rob Williams, a spokesman for New Hampshire Yankee, which operates the plant for its 12 utility owners. The plant was completed in 1986, 10 years and $4.6 billion after construction began. Licensing was held up over the refusal of Massachusetts officials to participate in emergency planning, which has cost an estimated $2 billion in interest payments since 1986, Williams said.

On Nov. 1, the Environmental Protection Agency, Washington, D.C., gave the Department of Energy (DOE) permission to operate the Waste Isolation Pilot Plant, about 650 meters below the New Mexico desert. The plant was designed to hold more than a million 208-liter barrels of waste, including transuranic nuclear waste ["Learning from Nature," *IEEE Spectrum*, July 1990, p. 23]. Before the DOE can operate the repository, however, it must gain custody of the land above it from the Department of the Interior; this is expected to take months, if not years.

The DOE, which has been encouraging the development of a new generation of more standardized, modular, and safer reactors, also awarded Westinghouse a $50 million grant to continue work on its AP 600. This 600-MW prototype reactor has so-called passive safety features; it was designed to rely on natural forces, such as gravity, to cool itself indefinitely in the event of an accident. Westinghouse claims that a plant could be built around an AP 600, with factory-built modules, in five years.

Whether the industry will ever get the chance to put Westinghouse's claims to the test is unclear. On Nov. 3, the United States Court of Appeals for the District of Columbia overturned a decision by the Nuclear Regulatory Commission (NRC) that would have allowed utilities building a nuclear plant to skirt much of the postconstruction licensing process if they were using a standard, preapproved design. The NRC agreed to the licensing change in 1989 as part of an effort to encourage a revival of the nuclear industry based on standardized designs; these designs might include Westinghouse's AP 600 and similar systems under development by Framatome and other reactor makers. Observers noted that the issue is somewhat academic, however, since there have been no nuclear plant orders in the United States in 12 years.

Fires at U.S. utilities

Electrical fires in substations were the cause of three major midsummer power outages in the United States, two on Chicago's West Side and one in New York City's downtown financial district. In Chicago, the trouble began Saturday night, July 28, with a fire in switch house No. 1 at the Commonwealth Edison Co.'s Crawford substation, according to spokesman Gary Wald.

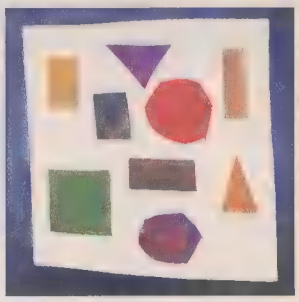
Some 40 000 residents of Chicago's West Side lost electricity. About 25 000 had service restored within a day or so and the rest, within three days. However, as part of the restoration, Commonwealth Edison installed a temporary line configuration around the Crawford substation. But when a second fire broke out on Aug. 5 in a different, nearby substation, some of the protective systems that would have isolated that fire were inoperable because of that configuration. Thus, what would have been a minor mishap resulted in a one-day loss of power to 25 000 customers—the same 25 000 whose electricity was restored first after the Crawford fire.

The New York outage began around midday on Aug. 13, after an electrical fire broke out in switching equipment at Consolidated Edison's Seaport substation, a point of entry into Manhattan for five 138-kilovolt transmission lines. To interrupt the flow of energy to the fire, Edison had to disconnect the five lines, which cut power to four networks in downtown Manhattan, according to Con Ed spokeswoman Martha Liipfert.

Power was restored to three of the networks within about five hours, but the fourth network, Fulton—which carried electricity to about 2400 separate residences and 815 businesses—was out until Aug. 21. Liipfert said much of the equipment in the Seaport substation will have to be replaced, at an estimated cost of about $25 million.

Mounting concern about underground electrical vaults in some areas was tragically validated by an explosion in Pasadena, Calif., that killed three city workers in a vault. Partly in response to the explosion, the California Public Utilities Commission adopted new regulations last Nov. 21 requiring that utilities in the state set up formal maintenance programs, inspection intervals, and guidelines for rejecting decrepit or inferior equipment. "They have to maintain a paper trail, and we as a commission will do inspections of underground vaults and review their records to make sure they're maintaining their vaults and equipment in good order," said Russ Copeland, head of the commission's utility safety branch. ◆

CONSUMER ELECTRONICS



Digital HDTV: a late but impressive entry
The home theater concept blossoms
Fuzzy logic for varied products
Ease of product use finally gets attention

The simmering U.S. waters of high-definition television (HDTV) heated to full boil in June when General Instrument Corp., San Diego, Calif., announced its all-digital DigiCipher system for transmitting a full HDTV signal in digital format over a standard 6-megahertz television channel. This capability makes the DigiCipher system a contender for the simulcast HDTV standard mandated by the Federal Communications Commission (FCC), where one broadcast channel carries a standard National Television System Committee (NTSC) channel for reception on existing television receivers, and a second channel carries the HDTV signal that can be received only on HDTV sets.

In November, the Advanced Television Research Consortium —NBC, David Sarnoff Research Center, Philips Consumer Electronics Co., and Thomson Consumer Electronics Inc.— announced that an advanced digital television system would be developed jointly by the David Sarnoff Research Center, Princeton, N.J., and Philips Laboratories, Briarcliff, N.Y. The digital simulcast development program, the announcement stated, "will be accelerated to meet the FCC Advisory Committee testing schedule." Other advanced television system competitors in the United States have also expressed interest in presenting all-digital versions of their systems to the FCC for testing.

FCC laboratory testing of all proposed systems is now set to begin in April. A new schedule released in November by the FCC [Table 1] does not include any all-digital systems other than DigiCipher. But of the six systems to be tested, there could be as many as four all-digital systems—if their proponents can ready them in time. In addition, there is one analog simulcast system and one enhanced NTSC system. Laboratory testing will take place at the Advanced Television Test Center, Alexandria, Va., on a sophisticated system that includes a 65-inch Hitachi rear-screen projector and an ingenious Tektronix format converter—it permits several incompatible forms of advanced television signals to be recorded in real time on a high-definition digital videotape recorder.

Ben Crutchfield of the test center told us that field testing of the six systems will take place after laboratory testing is completed. But when or how this will be done, he said, has not yet been determined.

An FCC decision on an HDTV broadcast standard is not likely before mid-1993. If that is the case, HDTV broadcasting might begin in 1994.

Ronald K. Jurgen Senior Editor

DIGITAL HIGH-DEFINITION TELEVISION TAKES OFF



WAYNE C. LUPLOW: EXPERT OPINION

'High-definition systems are core infrastructure technologies that cut across many industries.'

The most significant advances of 1990 were on the high-definition television (HDTV) front. Several transmission system developers, including a new entry in the broadcast standard race, announced plans to tackle the thorny technical issues associated with all-digital HDTV. By year-end, at least three of the five major HDTV proponents preparing for system testing were well on their way to full-digital approaches.

Although terrestrial broadcasting developments continued to be the most visible HDTV system development activities, progress was made in applying high-definition technologies to a variety of media, including cable, fiber, satellite, and video recording.

It was a turning point year in the HDTV standards race as Federal Communications Commission (FCC) chairman Al Sikes set a new, refocused technical agenda. The FCC focused on simulcast HDTV as the technology it intends to choose as the standard, strongly favored true high definition over "enhanced" approaches, and ruled out augmentation HDTV systems.

Sikes also established the specific timetable for selection of the U.S. terrestrial broadcast standard for HDTV, stating that system testing would proceed through 1991 and into 1992. The Advisory Committee on Advanced Television Services would be expected to make its recommendation to the FCC in the third quarter of 1992 and full commission decision would come in the second quarter of 1993.

While most of the public high-definition focus continues to be on television, important advances continue in high-definition systems, such as high-resolution cathode-ray tubes, flat-panel displays, semiconductors, and digital compression. These high-definition developments are core infrastructure technologies that cut across many industries.

Spinoffs of high-definition technology for conventional television intensified in 1990. Channel equalization (ghost canceling) development activities were initiated for National Television System Committee television by the National Association of Broadcasters, Washington, D.C., and the Advanced Television Systems Committee. New broadcast, satellite, and cable ventures—using video compression to squeeze more services into channels previously dedicated to only a single NTSC program—were announced. Others moved ahead on enhanced NTSC systems.

Last year also saw the long-awaited commercial introduction of digital audio tape, enhancements in home theater television, advances in simplified VCR programming, and more miniaturization in camcorders and personal electronics.

The economic downturn took its toll on consumer electronics as the industry's primary product category, color television, failed to reach the record unit sales volume expected earlier in the year. Even with the lower sales volume and healthy inventory levels, irrational pricing and the need to improve profitability remained the burning issues facing the consumer electronics industry.

Wayne C. Luplow (SM) heads Zenith Electronics Corp.'s high-definition television R&D program in Glenview, Ill. He is also a member of the Advisory Committee on Advanced Television Services, the Center for Advanced Television Services, and the Advanced Television Systems Committee. He is a member of the administrative committee of the IEEE Consumer Electronics Society and editor of the IEEE Transactions on Consumer Electronics.

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1. Advanced television test systems and schedule

Laboratory test period		ATV system/proponent/type	Scanning: lines/fields/raster format
Start testing	End testing		
April 12	June 12	ACTV: Advanced Compatible Television/David Sarnoff Research Center/E	525/59.94/1:1
June 19	Aug. 12	Narrow MUSE/NHK—Japan Broadcasting Corp./S	1125/60/2:1
Sept. 3	Oct. 24	DigiCipher/General Instrument Corp./S	1050/59.94/2:1
Oct. 31	Dec. 27	SC-HDTV: Spectrum Compatible HDTV/Zenith Electronics Corp./S	787.5/59.94/1:1
1992			
Jan. 8	March 3	Simulcast HDTV/N.A. Philips Consumer Electronics Co./S	1050/59.94/2:1
March 10	April 30	Channel Compatible HDTV/Massachusetts Institute of Technology/S	787.5/59.94/1:1

E—Enhanced NTSC S—Simulcast HDTV 2:1—Interlaced 1:1—Sequential

Why go digital?

There are economies and ease of production, editing, and transmission in the digital domain. James E. Carnes, head of the David Sarnoff Research Center, outlined other advantages of digital simulcast HDTV systems at the IEEE Media Briefing in New York City in November. They include improved picture quality due to superior signal-to-noise ratios and ease of encrypting digital signals over the air compared with analog signals.

These advantages are accompanied by problems, Carnes cautioned. A principal one is interference with standard NTSC signals. Consequently, he said, channel spacings will have to be reduced and questions also remain about interference of NTSC signals with digital signals. Further, it is not known whether robust and benign RF approaches can be designed. And, Carnes stressed, digital signals tend to degrade abruptly as distance increases from the transmitter, whereas analog signals degrade gradually. Still, Carnes said, digital is the way to go.

The DigiCipher system, according to General Instrument Corp., provides full HDTV performance with virtually no visible transmission impairments due to noise, multipath distortion, and interference. Low transmitting power can be used to take advantage of unused or unallowed (taboo) channels for simulcast transmission. The system can also be used for cable and satellite transmission of HDTV signals.

The key to compressing the HDTV signal into a single 6-MHz channel is a proprietary compression algorithm developed by General Instrument through extensive use of computer simulation. For error-free transmission of the digital data, powerful error-correction coding combined with adaptive equalization is used. At a carrier-to-noise ratio of more than 19 decibels, essentially error-free reception can be achieved. [For other system parameters, see Table 2.]

At the HDTV station [see illustration], the encoder accepts one high-definition video and four audio signals and text and transmits one 16-level quadrature-amplitude-modulated (QAM) data stream. A control computer supplies program-related information such as program name, remaining time, and program rating. At consumers' homes, HDTV receivers pick up the 16-QAM data stream and provide video, audio, and ancillary signals.

The digital video encoder accepts Y (luminance) and U and V (chrominance) inputs with a 16:9 aspect ratio and 1050-line, interlaced (2:1) format at a rate of 59.94 fields per second. The Y, U, and V signals are obtained from analog red-green-blue inputs by an RGB-to-YUV matrix, low-pass filtering, and analog-to-digital conversion. The sampling frequency for the Y, U, and V signals is 51.80 MHz.

The multiplexer combines the various data streams into one at 15.8 megabits per second. The forward-error-correction encoder adds error-correction overhead bits and provides 19.42 megabits per second of data to the 16-QAM modulator. The symbol rate of the 16-QAM signal is 4.86 MHz.

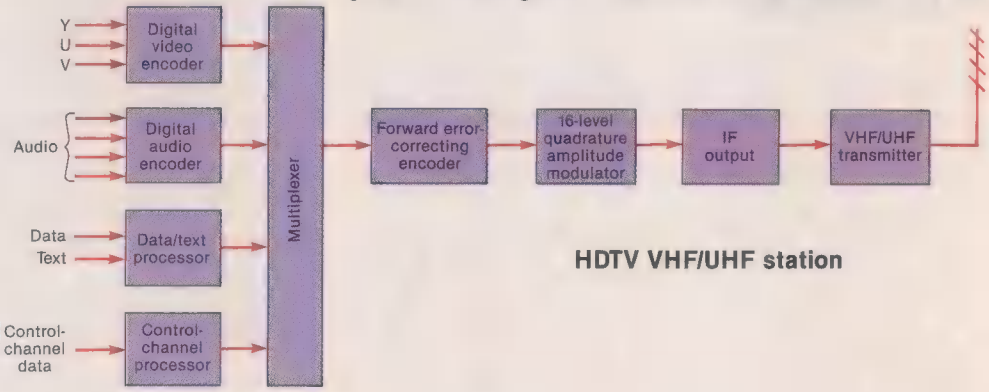
In the decoder, the 16-QAM demodulator receives the IF signal from the VHF or UHF tuner and provides the demodulated data at 19.42 Mb/s. The demodulator has an adaptive equalizer to combat the multipath distortions common in VHF and UHF terrestrial transmission. Next, the FEC decoder corrects virtually all random or burst errors and passes the error-free data to the synch/data selector; it maintains overall synchronization and provides video, audio, data/text, and control-data streams to appropriate processing blocks. The control-channel processor then decodes the program-related information. The TV receiver's microprocessor accepts commands from the remote control unit and controls various functions of the decoder, including channel selection.

Meanwhile, in Japan and Europe

While the United States aims its main HDTV efforts at terrestrial broadcasting, Japan and Europe are launching satellite delivery of analog advanced television signals.

Japan's multiple sub-Nyquist encoding (MUSE) system for satellite delivery to homes in Japan is based upon a 1125-line, 60-field-per-second format that is incompatible with terrestrial broadcast systems. Moreover, as Carnes pointed out at the IEEE media briefing, the Japanese BTA-I (Broadcast Technology Association) system for broadcast of HDTV signals with a 4:3 aspect ratio is scheduled for implementation in the next year or so, and BTA-II for 16:9 aspect ratio pictures is waiting for a standard to be selected over the next few years.

At an international broadcast equipment show in Japan in November, local electronics companies introduced pricey MUSE products. Among them were Osaka-based Matsushita Electric



HDTV VHF/UHF station

Industrial Co.'s 36-in. HDTV set (4.5 million yen or US $34 900) and Tokyo-based Sony Corp.'s 36-in. set (2.3 million yen). Matsushita hopes to sell 50 sets a month in Japan. Sony aims for 100. The Sony set requires use of a separate HDTV decoder (1 million yen); the Matsushita set has one built in. But Japan is presently broadcasting HDTV only one hour a day, so the projected sales figures may be optimistic.

In Amsterdam, the Netherlands, in June, T.A.G. van Eupen, project manager of Nederlands Platform HDTV, summarized how HDTV would be introduced into the European broadcasting system. The participants in Eureka have opted for the multiplexed analog component (MAC) signal, he said, in which the various components of the sound and video signals are transmitted independently, one after the other, across the full bandwidth of the signal, and are then reconstructed in the television receiver.

RTL4, Luxembourg, started broadcasting in D2-MAC—an interim enhanced-definition system—in October. Viewers with dish antennas can receive the programs. The cable networks convert the signal into the PAL (phase alternate line) format so that cable viewers see no difference in their programming. In October 1991, van Eupen said, D2-MAC sets will be introduced in the 16:9 format and, in 1992, the first program to be broadcast in HD-MAC in Europe will be the Olympic Games in Barcelona, Spain. By 1993, there should be enough sets on the market to make practical test broadcasts of HD-MAC. Regular HD-MAC transmissions will start in 1995, he said.

But in November, British Satellite Broadcasting announced that it was merging with Sky Television and that the merged organization would broadcast in PAL, the UK's existing broadcasting system, rather than D2-MAC. Philips of the Netherlands subsequently sued British Satellite Broadcasting and Sky Television for losses it said it had incurred as a manufacturer of D-MAC equipment.

HIGHLIGHTS

Success: Advances in simplified videocassette-recorder programming solved one of the VCR user's most frustrating problems.
Shortfall: Color television sales failed to reach the record unit sales volume expected earlier in the year.
Notable: General Instrument Corp. proposed an all-digital high-definition television broadcast system for the United States that sparked all-digital approaches by other proponents of systems for Federal Communications Commission testing.
Newsmaker: Al Sikes, chairman of the FCC, who said it would consider only simulcast systems for a U.S. terrestrial high-definition television standard, thereby ruling out augmentation systems.

Home theater

In the existing consumer electronics marketplace, the home theater concept, which combines large-screen video displays with precise reproduction of movie sound tracks, is gathering momentum. One of the new entries was the THX home theater sound system from Lucasfilm Corp., Nicasio, Calif., which uses a series of proprietary electronic and loudspeaker developments. Technics, Secaucus, N.J., was the first company licensed by Lucasfilm to manufacture THX products. Its system, with a retail price of $12 000, consists of a THX controller; three stereo power amplifiers; front left, center, and right speakers; a subwoofer; and two surround speakers.

Earlier in the year, Mitsubishi Electric Sales America, Cypress, Calif., introduced a 120-in. rear-view projection television system. The model VS-12001 costs about $20 000, depending on the scope of the custom installation. Set in ■ frame that mounts flush with the wall, the display requires a dedicated area behind it about 2.4 meters deep for the rear projection system.

At the heart of the Mitsubishi projection system is an electromagnetic-focus electron gun that minimizes distortion and eliminates blooming of the focal point at peak brightness levels. A dynamic focus circuit produces crisp, clean images at the edge of the screen. Liquid cooling and optically coupled lenses eliminate reflection between the glass surfaces of the cathode-ray tubes and the lenses. The system provides 750 lines of horizontal resolution.

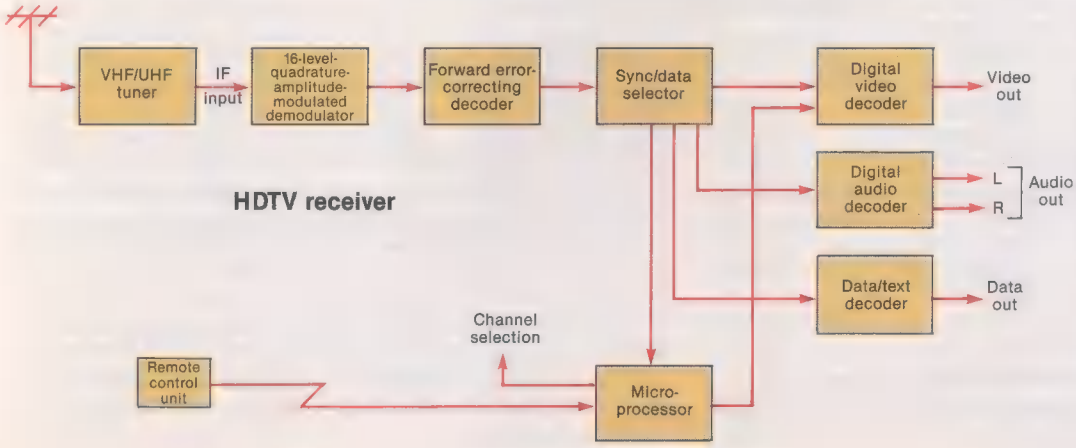
For the video portion of ■ home theater system, Barco Inc., Kennesaw, Ga., introduced the Barco-vision 1500-C HDTV video projector ($19 995). By pressing ■ button, the viewer can switch between standard video's 15.7-kilohertz horizontal scanning rate and any proposed HDTV format, all of which fall between 30 and 35 kHz. Since the projector's optical resolution is 2200 horizontal lines, it can also accommodate the resolution of any proposed HDTV format. The user can choose the aspect ratio of the picture—either 4:3 broadcast standard or 16:9 wide screen—and the projector is compatible with Scan doublers used in improved-definition television systems.

In a lower price range, Philips Consumer Electronics Co., Knoxville, Tenn., unveiled WallVision, with rear-projection units that can stand alone or be installed directly into a wall through use of accessory kits. A basic kit, costing $199.95, consists of a screen frame, a slip-on color enhancement filter that also protects the screen, a speaker grille, an air dam to control internal air flow through the system, and an installation and hook-up guide. A wall-mounted equipment cabinet with fans that houses audio and video components is $300.

Kits are available for three projection system sizes—46 in. (Model 46LP4OSA, $3000), 52 in. (Model 52LP5OSA, $3300), and 61 in. (Model 61LP9OSA, $3700), all of which employ a 50-watt Dolby Pro-Logic surround sound audio system. Approximately 75–85 centimeters of space are needed behind the wall for installation.

Fuzzy logic, anyone?

Neural networks and fuzzy logic technology made a splash in such consumer products as camcorders, room air conditioners, vacuum cleaners, and washing machines introduced last year. (Neural networks represent data and decision structures like a neural system, with relative weights assigned to data. Fuzzy logic



General Instrument Corp.'s DigiCipher digital HDTV system compresses all digital data into a single 6-MHz television channel for simulcast high-definition TV broadcasting.

is a branch of logic that uses degrees of membership in sets rather than a strict true-false membership.)

Sanyo Fisher (USA) Corp., Chatsworth, Calif., unveiled the FVC-880 8-mm, 1.7-lb (0.8 kg) camcorder ($1299.95) with artificial intelligence circuits and fuzzy logic for automatic iris and focus control. In contrast to yes-no circuits, fuzzy logic allows fast evaluation of focus and lighting, as well as improved video reproduction in backlit scenes.

Matsushita introduced the CS-XG and CS-SG series of heat-pump room air conditioners, which use neural-network and fuzzy-logic technology to create the most comfortable room environment possible. In the XG series, for example, the unit's microcomputer has a neural network. The microcomputer's memory stores 4608 control patterns derived from research on the most comfortable operation for a wide variety of room sizes, indoor and outdoor temperatures, and so forth. When it is freezing outside, for instance, the unit automatically increases its performance to optimize the environment faster than does a conventional air conditioner.

Fuzzy logic improves defrosting control in both series. When a room is being kept warm when temperatures outside are low, frost piles up on the evaporator in the air conditioner's outdoor unit. Conventional systems perform defrosting operations at regular intervals during such conditions. But in the Matsushita air conditioners, the fuzzy logic evaluates the outdoor temperature, the temperature of the evaporator unit, and other factors and then chooses the most efficient intervals for defrosting.

The CS-XG series models went on sale in Japan in November with retail prices of 272 000 yen for the XG28E model and 310 000 yen for the XG32E2 model. (At the time of writing, the yen was hovering around 130 to the U.S. dollar.) The CS-SG series models SG22A and SG22E went on sale last month at a price of 185 000 yen. Models SG25A and SG25E went on sale this month at 200 000 yen.

Also in the Japanese market, Matsushita introduced in Japan vacuum cleaners with fuzzy logic. The three "Canister 7" MC-S72 units perceive both the condition of the floor and dust quantity with a fuzzy-logic dust sensor, which uses a microcomputer to control absorption power. The retail prices for the Japanese market are 58 000 yen for the MC-S72VPK, 54 000 yen for the MC-S72VP, and 44 000 yen for the MC-S72VC.

And Matsushita has incorporated fuzzy logic in a fully automatic washing machine. Called Aisaigo Day Fuzzy, it is equipped with two optical sensors that can sense the quality and quantity of dirt. With the cloth-quality sensor, the 83 000-yen machine can perceive the size of the load and the type of detergent (liquid or powder). On the basis of this information, the microcomputer with the fuzzy control selects the most suitable of about 600 different ways to wash the clothes.

Help for the consumer

A big problem with consumer electronic products has always been how to connect them up and use them. As these products have proliferated in recent years, the confusion has compounded. But there are some glimmers of hope for the befuddled consumer. For example, some videocassette recorders (VCRs) on the market can be programmed with bar-code readers. And with VCR Plus+, a remote control device from Gemstar Development Corp. ($59.95–$69.95), a user can program a VCR by simply keying in a code number that appears opposite the program to be taped in many newspaper listings. The device makes use of a mathematical algorithm that converts the code numbers to the proper time slots and channel numbers.

In a technological innovation, Matsushita unveiled a voice-interactive programming VCR at the Japan Electronics Show '90 in Tokyo in October. The VCR uses advanced voice recognition/synthesis technology that can understand the speech of an unspecified speaker—one whose speech pattern has not been preregistered with the VCR.

Programming a VCR is to many people one of the most frustrating tasks imaginable. But with the Matsushita unit, it is simple. Programming begins when the remote control in a synthesized voice tells the user how to start. It says, "We will now begin programming. What channel would you like to record?" The user then speaks a command—"Three," for example. The spoken exchanges continue through each phase of the input process, including selecting the day and starting and ending times. Confirmation that the programming has been done correctly appears on the remote control unit's liquid-crystal display. The final result is verified by the display and by the synthesized voice, which says, for example, "You have programmed to record Channel 3 on Thursday from 7:00 p.m. until 8:55 p.m."

Ease of use is also one of the hallmarks of audio-video receivers. They have been around for several years but with the proliferation of VCRs, laserdisc players, camcorders, surround-sound amplifiers, and so forth, they are more valuable than ever. The newer units include Dolby Pro-Logic surround sound and users can connect all of their audio and video equipment to the receiver and control the lot with just one easy-to-use remote control unit.

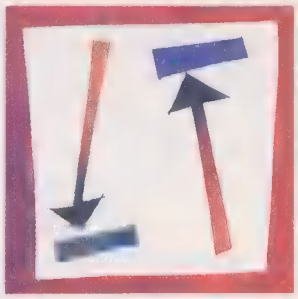
Dolby Pro-Logic was featured in the May introduction by Pioneer Electronics (USA) Inc., Long Beach, Calif., of its VSX-DIS audio-video receiver, which serves several rooms. The unit's twin 50-bit digital signal-processing system maintains signal purity during the processing of audio enhancements (such as Dolby Pro-Logic) to ensure optimum sound reproduction within five digitally simulated sound fields. Through use of an optional MR-100 infrared adaptor and a pair of speakers or a video monitor, the multiroom function allows listeners to access and operate separate sources from anywhere in the home at independent volume levels. Two persons, each with a remote control, can simultaneously command two different system components from separate rooms.

The system accommodates five audio inputs (compact disc, phono, tape-1, tape-2, and line) and six video inputs (VCR-1/-2/-3, videodisc player, television, and video), allows two-way dubbing, and includes S-video (Super VHS) terminals. Suggested retail price is $1350. ◆

DigiCipher simulcast HDTV system parameters

Parameters	Value
Video	
Aspect ratio	16.9
Raster format	1050/2:1 interlaced
Frame rate	29.97 Hz
Bandwidth Luminance Chrominance	 22 MHz 5.5 MHz
Horizontal resolution Static Dynamic	 660 lines per picture height 660 lines per picture height
Horizontal line time Active Blanking	 27.18 μs 4.63 μs
Sampling frequency	51.8 MHz
Active pixels Luminance Chrominance	 960(V) x 1408(H) 480(V) x 352(H)
Audio	
Bandwidth	15 kHz
Sampling frequency	44.05 kHz
Dynamic range	85 dB
Data	
Video data	14.38 Mb/s
Audio data	1.76 Mb/s
Async data and text	126 kb/s
Control data	126 kb/s
Total data rate	16.40 Mb/s
Transmission	
FEC rate	130/154
Data transmission rate	19.43 Mb/s
16-QAM symbol rate	4.86 MHz

TRANSPORTATION



Europe establishes new air traffic control system
Airbus confounds Indian Airlines
First MD-11 wide-body jet is delivered
English Channel bores join

Western European nations launched a project to unify and upgrade their air traffic systems in three stages from 1990 through 2005. The crash of an Indian Airlines Airbus A-320 was attributed to pilot error, a consequence of inadequate training. A new commercial aircraft, the MD-11, entered the market, while developments in rail technology, notably an underwater linkup between France and the UK, made some gains.

Handling more flights in Europe

To manage the increasingly heavy schedule of flights across Europe and over European airports and in air routes, the 11-member European Organization for the Safety of Air Navigation (Eurocontrol), is pressing ahead with an advanced integrated air traffic control system. Based in Brussels, Belgium, Eurocontrol expects the new system to handle more flights, forecast to double within 10–15 years, and save airlines fuel by reducing takeoff and landing delays as well as by shortening flight paths.

The system, called Enhanced Air Traffic Management and Mode S Implementation in Europe (Easie), will automate air traffic control functions. One of its central elements is the Aeronautical Telecommunications Network (ATN), which will link various subnetworks to provide transparent data communication between airborne systems (processors or the pilot) and ground air traffic control (processors or controllers). The subnetworks include the air traffic control ground networks, avionic networks, and the mode S data link, a U.S. standard for which many airlines have equipped their fleets with transponders to meet requirements for operating in U.S. airspace. Easie also handles satellite and very high-frequency signals.

Easie will be installed first in the busiest airports and airways—in Belgium, France, Germany, Luxembourg, the Netherlands, Portugal, England, and Wales. In time, the system may be extended to include Austria, Ireland, Italy, Malta, Spain, Switzerland, and the rest of Great Britain.

The design phase, to be completed in 1995, will describe the functions and integration of all system components. Implementation of the core area is expected to be completed by 2001.

Also, by 1995, the 23-member transport ministers of the European Civil Aviation Conference (ECAC) agreed in April that their national air traffic control systems must be able to communicate electronically in the areas having the highest traffic density—Belgium, France, Great Britain, Luxembourg, the Netherlands, and northern Germany. By 1998, such communication should extend to other members.

Airbus pilot training faulted

On a clear and sunny day in February, an Indian Airlines Airbus A-320 crashed upon landing in Bangalore, India, killing 90 people. The Indian director general of civil aviation immediately grounded the airline's fleet of 14 Airbus jets pending a Government investigation.

Three months later, a confidential report produced by a Government committee headed by Air Marshall S.S. Ramdas found that the twin-engine, 150-seat Airbus A-320, which took off from Bombay, had approached the runway at Bangalore airport at too low an altitude and at the wrong angle, according to Indian press reports.

The report faulted Indian Airlines, which serves India and neighboring countries, for not adequately training its pilots to fly aircraft as sophisticated as the Airbus, built by Airbus Industrie, Blagnac, France. The airline apparently accelerated the training of its pilots, engineers, and maintenance crew to operate its new Airbus fleet as soon as possible. The report is further said to have criticized Aeroformation, an Airbus subsidiary that provides initial pilot training, for not emphasizing the limitations of the aircraft. It recommended tightening requirements for pilot training.

Finally, the airport runway at Bangalore was not equipped with an instrument landing system to send radio signals to the aircraft's avionics for automatic landing. But even if it had been, the jet's position would have prevented contact.

In December, after the A-320 jets had helped in bringing back Indians trapped by the Persian Gulf crisis, Indian Airlines was allowed to fly its Airbus fleet again for regular passenger service.

More security for airports

In the United States, the focus was on security. The U.S. President's Commission on Aviation Security and Terrorism completed the investigation of air safety triggered by the bombing of Pan American World Airways Flight 103 over Lockerbie, Scotland, on Dec. 21, 1988. The commission found the U.S. civil aviation security system in need of major reform and the Federal Aviation Administration (FAA) inadequate in its anticipation of future threats. In its words, "Pan Am's apparent security lapses and FAA's failure to enforce its own regulations followed a pattern that existed for months prior to Flight 103, during the day of the tragedy, and—notably—for nine months thereafter."

The commission, chaired by Ann McLaughlin, former U.S. Secretary of Labor, recommended that FAA make it a top priority to develop equipment for detecting plastic explosives, the most likely cause of the Lockerbie explosion. It also advised deferring the FAA requirement that all U.S. carriers acquire thermal neutron analysis (TNA) machines for this purpose, because the Lockerbie bomb is believed to have been at most half the weight of plastic explosive that current TNA machines can detect.

MD-11 debuts

Last November, McDonnell Douglas Corp., based in St. Louis, Mo., delivered the first of its new MD-11 jets to Finnair Oy, the Finnish airline, a few weeks after the FAA certified the airplane. The MD-11 is the com-

HIGHLIGHTS

Success: The French TGV broke a speed record by achieving 520 kilometers per hour in trial runs along its new Atlantique line in May.
Shortfall: An Indian Airlines crash was attributed to inadequate training of the airline's pilots in flying its new fleet of Airbus A-320 jets.
Notable: Europe is pressing ahead with an advanced, integrated air traffic control system that will initially cover its busiest airports and airways and perhaps evolve to encompass Western Europe.
Newsmakers: The U.S. President's Commission on Aviation Security and Terrorism faulted the Federal Aviation Administration for lax supervision and Pan American World Airways for poor safety procedures in connection with the Lockerbie sabotage.

Katherine T. Chen Associate Editor

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pany's newest large commercial aircraft since the DC-10 was introduced in 1972.

In contrast to the DC-10, which has ■ three-seat cockpit, the MD-11's advanced flight deck obviates the need for a flight engineer seated behind the pilot and co-pilot, yet does not add to the burdens on the pair, according to McDonnell Douglas. Like the jets introduced in the 1980s, the MD-11 has a two-seat cockpit with automatic system controllers in overhead panels that monitor and configure the fuel, hydraulic, electric, and environmental systems. Each system is controlled by two redundant computers and is independent of the other systems.

What is unique about the MD-11 is the sophistication of the manual system to which the systems revert when both computers fail. To date, it is the most advanced backup system in the industry, the company said. It is comparable to the controls a pilot would have to maintain routinely in the two-seat cockpit of aircraft introduced in the early 1980s, said Joseph Ornelas, manager of MD-11 flight tests.

In addition, the flight deck computer has been programmed to take corrective action whenever necessary. For instance, if one of the six cathode-ray tube displays failed, the computer would reconfigure the other five to include data from the blank screen, obviating manual correction by the pilot.

The MD-11, moreover, is claimed to be the first commercial aircraft to have a universal cockpit design. This will allow different airlines to use identical simulators to train pilots for the new jet—a two- to four-week process. Easier maintenance and resale are other advantages. And system integration is enhanced because all the avionics systems were supplied by the same company, Honeywell Inc., Minneapolis, Minn.

McDonnell Douglas has 375 commitments for the tri-engine, 400-passenger aircraft, which is manufactured at the Douglas Aircraft Co. in Long Beach, Calif.

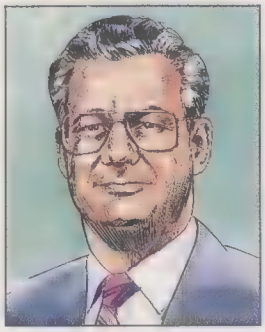
No new aircraft will emerge from its competitors, Airbus Industrie and Boeing Co., Seattle, Wash., for several years. In late 1992, Airbus Industrie plans to deliver the A340, ■ long-range, four-engine aircraft that can seat 295 passengers, while the A330, a short-range, twin-engine jet for 335 passengers, is scheduled for delivery in 1993. And the dominant Boeing Co. received its first order from United Airlines for 34 Boeing 777 twin-engine jets, which will seat up to 390 passengers; delivery is expected in mid-1995.

Chunnel linkup

Construction of the threefold tunnel beneath the English Channel linking Folkestone, Great Britain, and Calais, France, passed another milestone in December when the two ends of the service tunnel met. A metal probe directed by a laser guidance system aligned the final section of the service tunnel, which is located between the two railway tunnels. The two railway tunnels are expected to be completed this fall, and trains are to begin running in June 1993.

Another rail development in Europe was delivery to Sweden's State Railways of ■ 200-km/h train that is expected to ferry travelers between Stockholm and Gothenburg in less than 3 hours, down from 4 hours. Manufactured by Asea Traction AB, based in Vasteras, Sweden, the X 2000 will race over existing tracks, in contrast to the high-speed French Train à Grande Vitesse (TGV),

A YEAR OF EVOLUTIONARY CHANGES



ANTHONY R. EASTHAM: EXPERT OPINION

'The TGV demonstration provided convincing evidence that high-speed rail can be developed beyond the current operational speeds of nearly 300 km/h.'

Transportation is a sector that seldom experiences ■ breakthrough. It uses advanced technologies that have been developed for more general purposes to produce incremental enhancements.

For instance, transportation uses such advanced materials as composite-layer structures for car bodies and thermoplastics for low-friction bearing surfaces in rail trucks; expert systems for troubleshooting and maintenance operations; computer-aided design for vehicle component layout; and digital techniques with multiplexed cable or optical fiber train communication and control lines.

Other technologies borrowed from ■■■ satellite communications for surveying and vehicle location and identification; materials for improved track and roadbeds; improved motor and power conditioner design; microelectronic implementation of new control algorithms; and aerodynamics for better energy use.

While change in transportation is usually evolutionary rather than revolutionary, 1990 has provided us with some identifiable technology milestones. Most significant, perhaps, was the demonstration that high-speed rail is capable of very high-speed operation. A modified Train à Grand Vitesse (TGV) achieved ■ speed of 520 kilometers per hour (320 miles per hour) on May 18, 1990, during a series of trial runs between Courtalain and Vouvray on the new Atlantique line southwest of Paris. While TGV does not plan to introduce passenger service at such high speeds, the demonstration provided convincing evidence that high-speed rail can be developed beyond the current operational speeds of nearly 300 km/h.

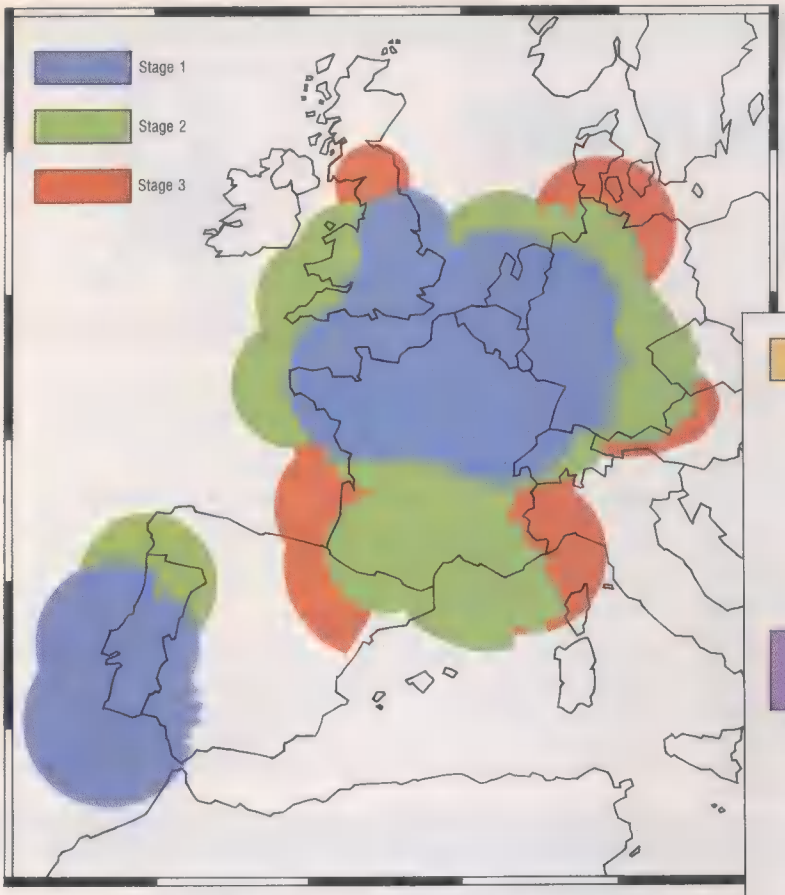
Meanwhile, development of magnetic levitation systems continues. The 400–450 km/h electromagnetically suspended (attraction mode) vehicle by the German consortium Transrapid is in its final stage of preproduction testing and may be implemented by the mid-1990s. In Japan, 340 billion yen (US $2.5 billion) has been committed for the construction and operation of a 40-km-long test track in Yamanashi prefecture, 70 percent of which will be in a tunnel. The 500-km/h electrodynamically suspended (repulsion mode) technology supplied by Linear Express will be tested under operational conditions. This test track could form part of a new Chuo line, supplying 500-km/h (1-hour) service between Tokyo and Osaka early in the next century. While both maglev systems could be considered revolutionary, they have been evolving over the past 25 years.

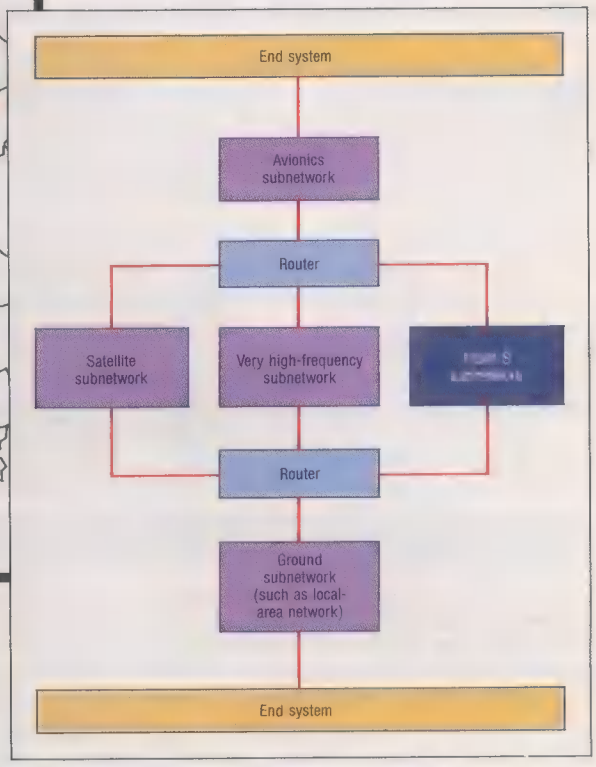
Will there be a renaissance in high-speed ground transportation (HSGT) in North America? Growing gridlock on our urban and inter-urban arterial roads, and congestion in many air lanes and terminals, suggest ■ developing market for HSGT ■■ a complementary mode in many high-population-density corridors. Transportation infrastructure and financing options in many such corridors are being examined in detail in North America and in industrializing countries such as South Korea.

While the need for affordable new technologies is certainly a substantive factor driving change in transportation, legislation can provide the greatest impetus for development. Thus, the public mood in California and elsewhere to improve air quality has led to legislation aimed at reducing vehicle exhaust pollutants.

This is providing a stimulus not just for better automotive catalytic converters but also for renewed R&D efforts on electric vehicles. We will ■■■ increased attention paid to a systems approach, involving the integration of improved energy sources, power conditioning, control, and drive technologies. In addition, the use of gasoline taxes for the public-transportation infrastructure would provide ■ boost to the transit industry.

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Eurocontrol's Enhanced Air Traffic Management and Mode S Implementation in Europe (Easie) will link air traffic control ground networks, avionic networks, and the standard required for operation in U.S. airspace, Mode S data links. Easie, expected to expand in three stages from 7 to 13 nations, will provide transparent data communication through its Aeronautical Telecommunication Network (inset).

for which new dedicated alignments were required.

To negotiate curves at high speeds, the new train tilts its passenger cars. An accelerometer on the front car sends signals to hydraulic tilting actuators on each passenger car to minimize centrifugal forces. Like other European trains, the X 2000 uses ac propulsion, which requires lower maintenance than dc drives and is capable of feeding energy back into the line when the train is braking.

Beginning in December 1990, X 2000 trains are to be delivered bimonthly through early 1994. By 1992, the State Railways plans to introduce the train on its Stockholm–Malmö line.

Some other developments, according to the High Speed Rail Association headquartered in Pittsburgh, include the French TGV Atlantique line's extension from Le Mans to Mons, near Tours, which was opened in late September to complete the line from Paris.

Also in the works in Europe is a high-speed line between Barcelona and French border cities on which a variation of the TGV train will run at 299 km/h. In Germany, Intercity Express will begin operation along the Hamburg-Munich line this June. Italian Railways meanwhile is testing the new ETRY500 high-speed train. And the Soviet Union also has plans for a high-speed train linking Moscow and Sheremetyevo; construction is expected to begin this year and be completed in 1996.

Trekking eastward to Japan, a $2 billion, 43-km test track for a magnetic levitation train that will use high-temperature superconductors is being built at Sakaigawa, a town in Yamanashi Prefecture 130 km west of Tokyo. The test track, much of which will tunnel through mountains, will eventually be extended to link Tokyo and Osaka. The 523-km journey is expected to take less than two hours—considerably less than the three-hour trip currently offered by the 26-year-old Bullet Trains. The older trains, which are so popular that passengers often have to stand, will remain in service on separate tracks, because the new train is unlikely to enter service for decades.

Elsewhere in Asia, the South Koreans are stepping up efforts to build a long-proposed high-speed rail system to link Seoul with Pusan.

Then swooping down south to Australia, a consortium of Australian and Japanese companies has undertaken a study for a high-speed train whisking between Sydney, Canberra, and Melbourne. So far, the group has ruled against magnetic levitation. Its conclusions are expected later this year.

Returning north and across the Pacific, Canada's Bombardier Inc. said it has received financial backing from several Canadian and French banks for its proposed high-speed line between Quebec and Windsor. And in the United States, San Francisco's Bechtel Corp. has received a franchise to construct a high-speed magnetic levitation train connecting Los Angeles with Las Vegas. The 426-km journey is expected to take 75 minutes on a German Transrapid International train.

In addition, the Southeastern Pennsylvania Transportation Authority (Septa) in Philadelphia is still awaiting its rail car fleet, the first U.S. fleet with ac traction motors. Originally due in mid-1989, the cars were shipped by Asea Traction AB to Indianapolis, Ind., for assembly by Amtrak.

While high-speed passenger trains have enjoyed the lion's share of attention, freight trains also have reaped some of the fruits of advancing technology. An automatic vehicle identification system by Harmon Industries Inc., Blue Springs, Mo., electronically scans a freight car's transponder at microwave frequency as it passes the scanner. Another device, a real-time monitoring system installed at crossings, sends a radio signal to a rail operator if a battery runs low or a malfunction occurs. Radio signals are beginning to replace wires for short-range communication. ◆

AEROSPACE / MILITARY



Conventional and strategic cuts deepen
Unmanned vehicles seek more autonomy
Lightsat launching gets a boost
Gamma-ray observation universal

The Cold War, that catalyst of so many aerospace and military developments since World War II, all but concluded in 1990. It did not mean the end of sizeable military budgets, but analysts in the United States, Europe, and the Soviet Union foresee that possibility. So defense contractors are beginning to look for commercial ventures.

Arms-control pacts notwithstanding, turmoil in the Persian Gulf dominated the military realm last year. Iraq's August invasion of Kuwait reminded the world's public that not all tanks should be turned into tractors. Two technology developments of the 1980s—night-combat capabilities and better control of electromagnetic signatures—may be critical to Gulf combat. Another ongoing trend, distancing humans from battle to reduce casualties, is expected to result in one of the few significant growth areas in the 1990s: unmanned vehicles. Space, also a robust area, saw the debut of an inexpensive launch vehicle called Pegasus, sponsored by the Defense Advanced Research Projects Agency (Darpa). And that spells good fortune for "lightsats"—small, cheap satellites.

In civilian aerospace, the Hubble Space Telescope debacle cast a long shadow ["The Media Event," p. 31], although some bright stellar images proved salvageable by computer reconstruction. Officials at the National Aeronautics and Space Administration (NASA) hope the next one of their four orbiting observatories, the US $550 million Gamma Ray Observatory, will be lofted without glitches in the first half of 1991. Commercial space ventures took off last year, and are changing the landscape for launching. Japan and Europe achieved notable successes with some spacecraft.

Military regrouping

A historic arms pact was signed in November by the Soviet Union, the United States, and their respective allies that limits the number of tanks, aircraft, artillery, and armoured vehicles in Europe. The limits will severely hamper any military offensive on the Continent. Accords on chemical weaponry and strategic nuclear weapons are also in the works.

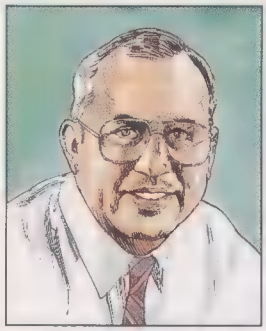
The first post–Cold War defense budget saw no cancellations of any large U.S. weapons systems. Pentagon outlays for fiscal 1991, not counting Persian Gulf costs, were to decline by $6 billion to $288 billion. Nevertheless, such observers as the Electronic Industries Association (EIA), Washington, D.C., predicted the defense budget will decline by one-third of its 1990 level. Similarly, a report by the Stockholm International Peace Research Institute in Sweden said that the West European arms industry may have to lay off as much as one-third of its work force. The Soviet Union defense industry is perhaps undergoing the most dramatic change ["Soviet officials visit Boston for ideas on arms conversion," THE INSTITUTE, December 1990, p. 3].

The EIA study noted that Pentagon planners are concentrating efforts on saving existing programs such as the B-2 stealth bomber. Retrofit and modification upgrades are not that much of a near-term priority, especially since arms control pacts will result in fewer old weapons. Two Advanced Tactical Fighter prototypes—one (YF22) by a Lockheed, Boeing, and General Dynamics team, another (YF23) by Northrop and McDonnell Douglas—debuted last year to begin a flyoff competition for an award this July by the Air Force. At stake is a $60 billion contract for 750 of the aircraft. The Navy's A-12 Avenger, a stealthy attack fighter being developed by General Dynamics and McDonnell Douglas, is suffering from cost overruns and turmoil in the Navy contract office.

In general, tactical programs fared better than strategic ones in Congress' fiscal 1991 budget. Congress whittled the Star Wars budget again this year, ignoring the Administration's $4.5 billion request and allotting $2.9 billion—the lowest funding in five years. After spending $20 billion, the Strategic Defense Initiative (SDI) has reached a stage of many tests. For example, last year saw the

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WHAT 'PEACE DIVIDEND'?



ROBERT S. COOPER: EXPERT OPINION

'The current distress in the aerospace and defense industry may be the catalyst, so far lacking, to awaken the U.S. government.'

Defense and aerospace technology was heavily affected this past year by world geopolitical changes, by a financial crisis in the Federal government, and by a plethora of technical and political failures related to U.S. government sponsored R&D initiatives. In October of 1989, the Berlin Wall came crashing down, followed in quick succession by declarations of independence of some of the USSR's 15 republics, the de facto dissolution of the Warsaw Pact, the formation of new democratic free-market institutions, the rapid withdrawal of Soviet troops and equipment from Eastern Europe, and the reunification of Germany.

Although Soviet strategic force modernization continued and formal treaties limiting strategic and conventional forces were not signed, U.S. citizens came to expect an instant "peace dividend" and a massive, rapid redeployment of the defense and aerospace resources. With congressional elections looming, Congress, instead of seriously addressing the industry's transitional problems, largely exploited the peace dividend issue politically; the result was a deadlock with the President over the defense budget.

Throughout this period, the primary questions that had to be addressed in the industry by technologists and businessmen alike were, "What impact will these cataclysmic changes have on me and my business?" and "What should I do to lessen their undesirable effects and take advantage of new opportunities?" Then, on Aug. 2, 1990, Iraq invaded Kuwait, providing what probably was some much-needed planning lead time to prepare for major readjustments to come. But this respite can only be temporary. What are the realities of the changes in store?

Views differ. Both realistic assessments and bold rationali-

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first tests of ■ ground-based interceptor rocket, a laser relay system to bounce beams from the ground to space mirrors and finally to targets and off the Airborne Optical Adjunct for tracking warheads in space. Many tests went awry, to the dismay of SDI officials, who nevertheless observed that such failures were to be expected in early tests of an ambitious program. One notable SDI feature was nuclear-driven energy weapons: after some $1.5 billion in expenditures since 1985 but little progress, Congress stopped development last year. These weapons had been touted by physicist Edward Teller as a major reason to begin the Star Wars project. Antisatellite weapons, both kinetic kill and laser varieties, are to keep going forward.

HIGHLIGHTS

Success: The Soviet Union, the United States and 20 other countries signed an accord—some called it an armistice ending the Cold War—to reduce tanks, artillery, and other conventional weapons in Europe.
Shortfall: No one realized the $1.5 billion Hubble Space Telescope was balky until it reached orbit.
Notable: Japan's space agency announced plans to establish a manned outpost on the moon by 2010 with a view toward permanent settlement.
Newsmaker: Saddam Hussein, Iraq's ruler, reminded a world entranced by cooperation of the blunt power of military force when he invaded Kuwait and jeopardized the West's flow of oil.

In the conventional arena, the EIA forecast predicts unmanned vehicles to be one of the few significant growth areas for platforms in the 1990s. For example, simple and effective drones are being used at land and sea for aerial surveillance in the Gulf. A sophisticated underwater version sponsored by Darpa, Arlington, Va., and built by the Charles Stark Draper Laboratory Inc., Cambridge, Mass., began testing last year. The Unmanned Undersea Vehicle is one of many subsea robot programs worldwide.

The Navy envisions many uses for free-swimming robots. Among those mentioned by Rear Admiral Daniel J. Wolkensdorfer, head of the Navy's antisubmarine warfare research, are: deploying and neutralizing mines; tracking enemy submarines and ships; and mimicking friendly submarines to befuddle a foe. Potential civilian uses include mapping offshore exclusive economic zones, aiding oilfield work, and monitoring the oceans ■ part of global climate-change research.

Darpa's Unmanned Undersea Vehicle was dropped into the ocean last year to begin tests, primarily from San Diego, Calif. The torpedo-shaped titanium vehicle, 36 feet (11 meters) long, displaces 15 000 pounds (6800 kilograms) and uses silver oxide-zinc batteries for its electric motor propulsion. It is "designed for high speed and long endurance," according to ■ Draper spokesman, who added that the vehicle uses advanced technologies in navigation sonar, ■ fault-tolerant vehicle controller, propulsors, and engine components. A Pentagon spokesman said three mission packages will be tested: a tactical acoustic system by Martin Marietta Corp., based in Bethesda, Md.; ■ mine-search system by Lockheed Corp.; and ■ remote surveillance system whose contractor is yet to be determined. Much of the work on these vehicles is classified; the Pentagon pulled a paper from an IEEE session last year by two Draper employees on control of the submersible at low speeds.

Power storage is ■ major limiting factor for many roving robots. So the Naval Surface Warfare Center, White Oak, Md., is trying to devise ■ rechargeable lithium-cobalt oxide battery with as much

zations underlie the strategic plans of large and small high-technology companies alike. An example is the variety of opinions on whether or not treaty verification equipment needs will provide a major new business opportunity to take up some of the defense slack. Proponents of this position point to the new legislative initiative sponsored by Senator David L. Boren (D-Okla.), chairman of the Senate Select Committee on Intelligence, to expand the programs contributing to high-technology verification through National Technical Means inspections. Others believe that on-site inspection provisions in treaties limiting arms buildup and open Soviet borders will provide access to territories and other sources of information formerly denied to intelligence. This will greatly decrease our reliance on the expensive technical systems for treaty verification and for the traditional science and technology assessment of the USSR.

Some companies are planning to invade civilian and commercial markets to exploit the technologies and experience they have gained in defense and aerospace. They point to the success of such small civilian-market-oriented companies as Magellan Systems Inc., Monrovia, Calif., and Trimble Navigation Ltd., Sunnyvale, Calif., which have built their entire business by marketing civilian applications of global-positioning-system navigation receivers.

Others, though, such as Northrop Corp., Los Angeles, in a recent declaration by its chief executive officer Kent Kresa, reaffirmed their intention to remain in the defense and aerospace business. Recalling abortive attempts to commercialize after the Vietnam War, Northrop is casting its lot with the fortunes of its politically troubled B-2 bomber and the highly competitive advanced tactical fighter programs.

As defense procurements are cut back, a chill has descended on those who have adopted ■ strategy of focusing marketing attention on the National Aeronautics and Space Administration (NASA) and its recently expanding share of the Federal budget. But last year, ■ series of technical problems plagued such NASA programs as the Space Shuttle, the Hubble Space Telescope, and the Venus mapping mission, prompting Vice President Dan Quayle, who heads the National Space Council, to call for ■ 12-member committee review of the beleaguered space agency's efforts. The committee's chairman, Norman R. Augustine, chairman of Martin Marietta Corp., Bethesda, Md., noted during the release of the panel's report in December that "NASA is not ■ troubled ■ some people suggest—nor ■ good ■ it will have to be to carry out the program we suggest." The committee urged a shift to unmanned launchers and a higher priority for scientific research, such as Mission to Planet Earth and planetary exploration.

Meanwhile, during these uncertain times, industry is in part looking to the Federal government for leadership to remain competitive and to help aerospace and defense-oriented companies enter new high-technology commercial markets. Will the Administration respond? The signals ■ mixed. On one hand, John Sununu, White House chief of staff, and Richard Darman, Budget Director, have spoken out publicly against ■ U.S. industrial policy, and the Department of Defense relieved Craig Fields, director of the Defense Advanced Research Projects Agency (Darpa) from his post for supposedly supporting such a policy.

Yet the Administration has accepted, without objection, a congressionally initiated program within the Department of Commerce to aid in technology transition by funding commercial high-technology joint ventures with industry, a sort of commercial Darpa. In addition, D. Alan Bromley, the President's science advisor, has endorsed a new Government High Performance Computing Initiative, which could pass for ■ attempt to marshal the nation's industrial computer technology resources for the next round in the international computer wars. This is clearly an industrial policy thrust.

If the focus on R&D technology is now destined to shift away from the Department of Defense after 45 years of concentration there, then a U.S. industrial technology policy and some new Government institutions are certainly necessary in the very near term. It may be that the current distress in the aerospace and defense-oriented industry may be the catalyst, so far lacking, to awaken the U.S. government to action.

Robert S. Cooper (F) is chief executive officer of Atlantic Aerospace, Greenbelt, Md., ■ defense electronics company he founded in 1985. Cooper directed the Pentagon's Defense Advanced Research Projects Agency, Arlington, Va., during the early 1980s and headed the National Aeronautics and Space Administration's Goddard Space Flight Center during the late 1970s. A member of IEEE Spectrum's *editorial board, Cooper received a Ph.D. from the Massachusetts Institute of Technology in Cambridge.*

as 2.5 times the energy density of that of silver-zinc. Other researchers believe fuel cells will be the best power source for long-range missions. One paper in the 1990 IEEE Symposium on Autonomous Underwater Vehicle Technology, held in Washington, D.C., cited a three-month mission covering 6000 nautical miles.

Because of ever-more-prodigious computing power in compact packages, these robots can often rely on such highly sophisticated machine intelligence ■■ expert systems and artificial intelligence. Neural networks are another technique for robotics, including voice and vision recognition. Last year, for instance, Sandia National Laboratories, Albuquerque, N.M., produced a neural net that distinguishes tanks from houses, trees, and cars on a model terrain board 91 percent of the time. The various aerial angles used in the tests included orientations never viewed before by the neural net. The image recognition from raw video takes about 4 seconds, at 2.5 billion connections per second, in contrast to about four hours on a standard scientific workstation like ■ Sun 3. Sandia is examining ■ next-generation design to push speed beyond a trillion (10^{12}) connections per second. Other institutions, like Lincoln Laboratory, Lexington, Mass., are also investigating neural-net image recognition for national security and biomedical applications.

Dwindling military budgets are giving simulation an even more important part to play in evaluating various prototypes or technical upgrades in the early stages of the work. Don Gum, chief of the control integration and assessment branch at Wright-Patterson Air Force Base in Ohio, noted that simulations also allow operational pilots to examine the technology "and then tell the engineers how it can be best used in combat missions."

Commercial space endeavors

The small-is-beautiful creed got added strengthening last year in the satellite industry with the successful first launch of the Pegasus booster. Pegasus is a Darpa-sponsored winged rocket launched from an airplane into space carrying what are called lightsats of weights below 500 kilograms. It is built by Orbital Sciences Corp., Fairfax, Va., and Hercules Aerospace Co., Magna, Utah. A Pegasus launching should cost about $8 million and take no more than three days. Darpa is also sponsoring ■ larger launcher at Orbital Systems Corp. called Taurus with ■ still-speedy lift-off goal of eight days.

Darpa is to launch seven 47-lb (21-kg) "microsats" built by Defense Systems Inc., McLean, Va., on Pegasus' second flight in January. These quickly launched communications satellites could help battlefield users, once proven several years from now, according to Darpa. The first Pegasus commercial customer, in 1992, is to be a Swedish "Freja" auroral research spacecraft, previously slated to be boosted by China's Long March rocket.

Many other lightsat schemes ■re being considered or are under development, among them: the SDI's "Brilliant Pebbles" plan for some 4600 orbiting interceptors; Los Alamos National Laboratory's Alexis project for an array of tiny imaging spacecraft for arms control; Motorola Inc.'s Iridium project of 77 lightsats for worldwide cellular phone communications; and NASA's Small Explorer program, where lightsats will be launched starting in 1992 to give young scientists more access to space.

Pegasus is only one of the new launching alternatives for commercial space ventures. Martin Marietta began its first public space venture, Commercial Titan Inc., with ■ first launching on New Year's Eve in 1989. General Dynamics Corp.'s Commercial Launch Services, of San Diego, Calif., lofted its first commercial Atlas last July and is viewed as ■ major competitor to Europe's Arianespace. McDonnell Douglas Corp., St. Louis, Mo., continued its Delta II commercial launchings, which, at roughly $50 million ■ flight, save the Pentagon $13 million to $17 million compared with previous launches using NASA/U.S. Air Force controllers.

Arianespace continued to dominate commercial space operations in 1990. It launched six rockets, which carried nine primary spacecraft. Both Ariane and Titan rockets had misfirings last year. Arianespace's destroyed cargo of $189 million was the largest prospective loss in space insurance history, but that did not increase the premiums, which now run about 20 percent of spacecraft value (compared with about 4 percent in 1983).

Borderless space is forging ■ number of partnerships. Last February, an experiment in automated protein-crystal growth from Payload Systems Inc., Cambridge, Mass., became the first U.S. commercial cargo to be orbited aboard the Soviet Mir space station. The Soviets are negotiating with United Technologies Corp., Hartford, Conn., and Australian interests to build and operate a commercial launch site at Cape York, Australia. The Cape York Space Agency would initially offer launches on the Soviet Zenit 2 (SL-16) booster. Each launch of a satellite up to 15 700 kg into low-Earth orbit would cost $70 million.

The defense systems unit of Unisys Corp., McLean, Va., and Energetics Satellite Corp., Englewood, Colo., announced plans last November to build and operate a geostationary satellite system offering to track cargo carried on ships, trains, or trucks and to remotely monitor such features as utility lines and pipeline flow. Operation is expected to begin in the mid-1990s. Houston-based Space Commerce Corp. is to provide launch services using Soviet Proton vehicles, subject to U.S. government approval, at ■ cost of $56 million each for eight launches.

In addition to its Hubble telescope problems, NASA was bedeviled with the space shuttles Atlantis and Columbia, which were repeatedly delayed, disassembled, reassembled, rescheduled, and further delayed by mechanical and scheduling problems.

The agency's Magellan radar mapping mission to Venus began badly when ground controllers kept losing contact with the spacecraft. But after careful tending, the orbiter has produced detailed images of the perpetually cloud-shrouded Venusian surface, with expected surprises to planetary geologists.

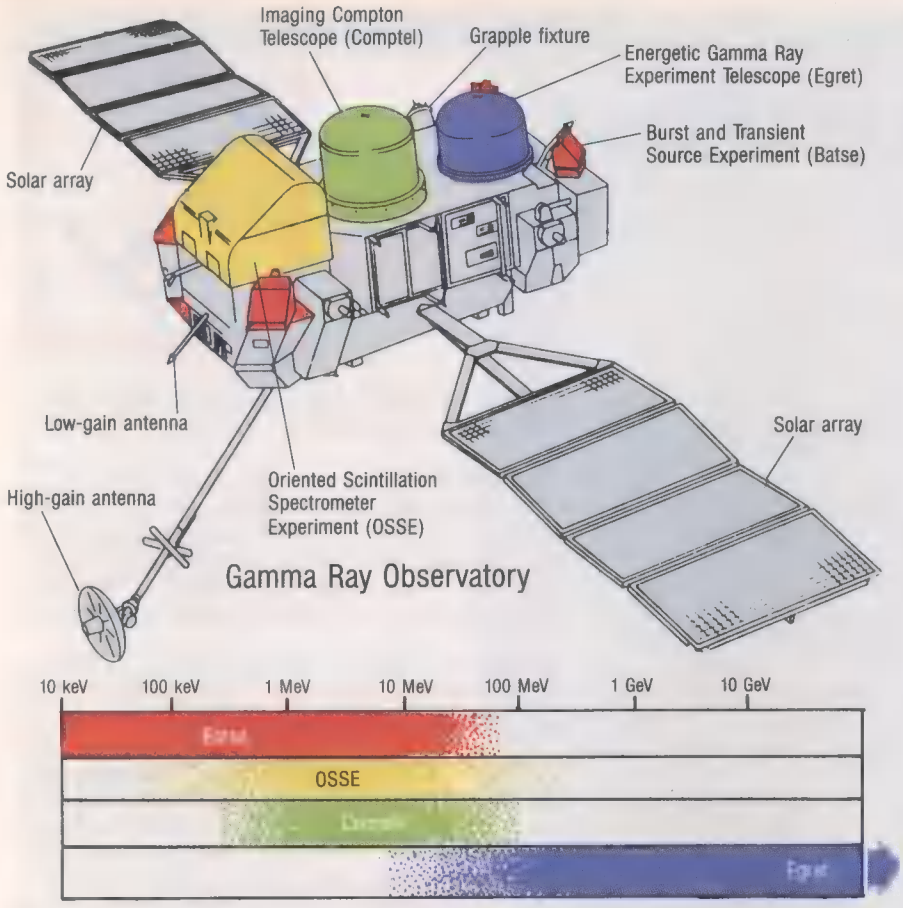
A much-needed success for NASA was its recovery of the Long Duration Exposure Facility (LDEF), the first of a spacecraft designed to be released and retrieved by another spacecraft. It was released by the Challenger shuttle in 1984, but its planned 1985 recovery was delayed by the grounding of the shuttle fleet after the Challenger disaster that year. The $400 million LDEF, which carried 57 experiments, was only weeks away from reentry into Earth's atmosphere.

Congress allocated $13.9 billion to NASA for 1991, a 13 percent rise, nine percentage points lower than the jump proposed by the Bush Administration. The legislators gave $1.9 billion to the space station, compared with $1.8 billion for the 1990 appropriation. Calls in Congress for restructuring the station project as it underwent its preliminary design review were echoed by a 12-member committee led by Norman R. Augustine, chairman of Martin Marietta Corp., reporting to the Administration's National Space Council.

The Augustine committee recommended in December that NASA decrease its reliance on the shuttle and simplify design of the space station so its construction can be on ■ cheaper, "more evolutionary, modular basis." The station's main purpose should be life sciences, such as living in weightlessness, and secondarily, microgravity experimentation, including processing of new materials. Over its six years, the space station project has had six program managers.

A committee of the National Research Council, looking at long-term space efforts for the moon and Mars exploration also criticized current space transports, urging "a plan for gracefully phasing out the shuttle system." Because of chloride pollution of the atmosphere by solid-propellant boosters, it recommended development of a reliable liquid-fueled rocket and work in nuclear thermal propulsion and nuclear electric power generation.

NASA's own Aerospace Safety Advisory Panel found that many safety problems "that could have been modified to reduce risk have been allowed to persist." If risks are not further reduced, the report said, another accident "will most likely occur." The panel is chaired by Joseph Sutter, former executive vice president of Boeing Aircraft Co. and a member of the Presidential Com-



The Gamma Ray Observatory, soon to be orbited, is the second (after the Hubble Space Telescope) of four spacecraft in NASA's Great Observatory program. Four instruments, from U.S. and German institutions, will view various bands of gamma radiation. It promises a unique view of the universe, particularly of dynamic objects such as black holes and neutron stars.

mission that reviewed the Challenger tragedy.

At $400 billion over 25 years, NASA's initial estimate for the Moon/Mars mission prompted a search for alternatives. (The Apollo Lunar Program cost $120 billion in 1990 dollars, when NASA's total budget was about 0.8 percent of the gross national product. Now the NASA budget is only about 0.3 percent of GNP, but it is rising.) One controversial idea from Lawrence Livermore National Laboratory, Livermore, Calif., was a permanent lunar outpost, using inflatable structures at a cost of $10 billion.

Lunar exploration got a big boost last May when Japan announced plans to land on the moon using robots by the year 2000. Japan hopes to construct a lunar base for humans by 2010. An important step toward that goal was the successful launch of the Muses-A lunar spacecraft last January on a Nissan M3S-2 booster from Japan's new Kagoshima Space Center in Tanegashima. This is the first lunar mission since the Soviet Luna-24 craft was launched in August 1976. The Japanese mission is testing both spacecraft design and tracking and control systems.

The Paris-based European Space Agency launched its Ulysses solar observatory from the space shuttle Discovery in October. Using two solid-fuel boosters, the 370-kg spacecraft was hurtled from low-Earth orbit toward Jupiter. A space launch was necessary because no combination of launch vehicles could impart the energy needed for a direct ascent to the orbit around the Sun's poles. Ulysses' December 1991 swing through Jupiter's powerful gravitational field will redirect its trajectory to approach the Sun's southern pole in April 1994. The orbiter is to examine for the first time solar phenomena at all solar latitudes, particularly at the unobserved north and south poles.

An important growth area for satellites is environmental remote sensing. France launched the 1870-kg SPOT-2 satellite last year. SPOT continues to compete strongly with the U.S. Landsat program, managed by Earth Observation Satellite Co. (Eosat), Lanham, Md. The new SPOT satellite uses three multispectral sensor bands covering 0.50–0.89 micrometer and has a high-resolution, wideband panchromatic mode (0.51–0.73 μm). The Landsat provides similar, but not identical, spectral coverage, but its spatial resolution is limited by archaic U.S. national security considerations to about 30 meters. SPOT's 10-meter panchromatic resolution has made it the darling of the world's television media during environmental and political crises.

ESA's Hipparcos, its first astrometry satellite, is working well despite failure of its apogee boost motor, which prevented transfer to the proper geostationary orbit. Stranded in a highly elliptical orbit, Hipparcos was initially given up for lost. But valiant efforts by the ESA controllers saved the mission. Soon after the boost failed, "we realized that the power system would face crucial tests around mid-March when the satellite would experience very long solar eclipses, during which Hipparcos remained in Earth's shadow," explained project manager Hamid Hassan.

But careful power management, directed from the ESA Operations Control Center, near Darmstadt, Germany, allowed Hipparcos to endure the longest eclipse of 105 minutes on March 16 without interruption of its tasks. It survived with barely five minutes remaining of onboard battery power, Hassan said. The spacecraft is designed to measure stellar parallaxes and proper motions of 100 000 stars to a precision of 2 milli-arcseconds.

If all goes as planned, NASA's Gamma Ray Observatory (GRO) will be launched in the first half of this year. It is the second (after Hubble) of four spacecraft in NASA's Great Observatory program for viewing the universe, from thermal infrared to the gamma rays, beyond atmospheric interference. At 15.3 metric tons, the GRO will be the heaviest payload ever deployed from the shuttle.

Because gamma rays are not attenuated as much as visible light or even X-rays by interstellar dust and gasses, the images should furnish a new, unobscured view of much of the universe, especially dynamic objects like neutron stars and black holes, which do not radiate in the visible spectrum.

GRO was assembled by TRW Inc., Redondo Beach, Calif., and carries four primary instruments. One scintillation spectrometer, by the Naval Research Laboratory, Washington, D.C., will look at low-energy gamma rays. The Burst and Transient Source Experiment, by the George C. Marshall Space Flight Center in Huntsville, Ala., is to monitor single and repetitive events with submillisecond resolution for study of emission mechanisms.

Also on GRO will be Germany's Imaging Compton Telescope, detecting gamma-ray photons between 1 and 30 million electron volts to provide directional determination and the imaging characteristics needed to study point sources. It was built at the Max Planck Institute for Physics, Garching, Germany. The fourth instrument, built by Max Planck Institute, Stanford University in California, and Goddard Space Flight Center, Greenbelt, Md., will observe the most energetic portion of the gamma-ray spectrum, up to 30 GeV, determining both direction and spectral energy distribution. The four instruments consume only 500 of the 1700 W provided by the 21.3-meter span of solar panels. ◆

MEDICAL ELECTRONICS



Computer-aided surgery experiments with robotics
Fast MRI promises real-time imaging
Ultrasound rebounds
Gallstone lithotripsy questioned

A combination of technological advances in magnetic resonance imaging (MRI) is unveiling new horizons for brain surgery. No longer seen as merely a diagnostic tool, MRI, which images soft tissues by applying a strong magnetic field and radio-frequency pulses to the body, is beginning to be viewed as a powerful adjunct in the operating room, providing positioning guidance and treatment feedback.

The use of MRI for detecting phosphorus and other elements in tissue, known as magnetic resonance spectroscopy (MRS), may have found its first clinical application in diagnosing coronary artery disease. New applications for ultrasound are cropping up as well, thanks to improvements in sensor technology. Last year also brought about steady advances in biomagnetic imaging.

Neurosurgeons have always used medical images to guide them in locating tumors and aneurysms. But the greater spatial resolution of MRI (now less than a millimeter), as well as improvements in three-dimensional reconstructions of MR images, have enabled physicians to rely more heavily on the images for presurgical planning. Radiologists at the University of Chicago Hospitals are fusing MRI and positron emission tomography (PET) images to give the surgeon a more complete picture of the patient's neurological landscape.

Thus, lesions and epileptic regions that can be seen only with PET (which detects chemical and metabolic activity) can be located with respect to anatomical landmarks that show up on the MR images. The Chicago radiologists are just beginning to integrate a third imaging method, MR angiography, which detects blood flow, to map the blood vessel network on top of the PET/MRI scan.

MRI 3-D reconstruction is proving more valuable than CT reconstruction because MRI can distinguish not just bone and tissue, as CT does, but also the different types of tissue, such as fat or lesions, and fluids, according to Ferenc A. Jolesz, associate professor of radiology at Harvard Medical School, Cambridge, Mass., and director of MRI at Brigham and Women's Hospital in Boston.

Jolesz' group has made significant improvements in MRI 3-D reconstruction by optimizing the way the 2-D images are acquired and processed in order to produce greater contrast between tissues when the images are reconstructed, according to radiologist Ron Kikinis, who is working with Jolesz. The imaging data are acquired in a double echo—a scan of the patient in which two different sets of brightness parameters are applied to better differentiate various tissues. The data then undergo a multi-stage image-processing procedure. First, they are filtered to reduce noise. Then, each pixel is classified into one of several user-defined groups—for example, gray matter, white matter, and fluids—by means of supervised multivariate analysis. (This technique was originally developed for processing remotely sensed images.)

Finally, a connectivity algorithm transforms the data into a 3-D volume. The 3-D images help the surgeon to navigate the best pathway into the brain, avoiding the motor cortex (injury to which can cause palsy or loss of visual or aural sensation), and to calculate the volume of tumors and other abnormalities.

Karen Fitzgerald Associate Editor

QUALITY OF LIFE TAKES THE SPOTLIGHT



CHARLES J. ROBINSON: EXPERT OPINION

'As issues involving sustaining life are settled, the concept of quality of life is coming to the forefront of biomedical engineering.'

The increasing sophistication of medical devices invokes awe even in those of us who are practitioners in biomedical engineering. Often such sophistication so overwhelms the general public and the medical profession that it crowds out other important considerations. As issues involving sustaining life are settled, the concept of quality of life is coming to the forefront of biomedical engineering. Though that concept has existed explicitly in the rehabilitation field for years, it has been only implicit in almost all other areas of biomedical engineering. The next decade will see many devices evolving out of this concept.

Perhaps the best way to define these quality-of-life improvements is to give specific examples from diverse areas. Cardiac pacemakers have been saving lives since the 1950s and are now being installed worldwide at a rate of 125 000 implants per year. Today, many people live longer because of them. Although some might argue that simply keeping patients alive is of prime importance, extending life need not mean a continuation of a productive life, especially if the pacing device has a limited ability to respond to different situations.

An advance in quality of life occurred here a few years ago when rate-sensitive pacemakers became available. To sense body motion to determine how fast the heart should be beating, these pacemakers currently use accelerometers, but these can be fooled into responding to environmental conditions (traveling over a bumpy road) or not responding in other circumstances (such as pedaling a stationary exercise bicycle).

Further gains will be made within the next few years as a number of pacemaker companies race to implement rate-sensing schemes based on physiological principles. These schemes require the development of new implanted sensors that can reliably measure such physiological factors as oxygen saturation, blood temperature, and respiratory rate. Since these endogenous parameters are used by the body to regulate heart rate, their appropriate use as inputs to a pacemaker could represent the ultimate in pacing control strategies that optimize quality-of-life possibilities.

Sometimes seemingly incremental gains in technology can lead to major gains in quality of life. To the public, a pacemaker with a battery life of six to eight years is marginally better than a pacemaker (or an automatic implanted defibrillator) with a life of four or five years. But, to the pacemaker user, it means far less surgery and perhaps much lower health care costs.

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Brigham and Women's Hospital

A Sun Sparc workstation simulates locating a tumor in the brain with a needle held in position by a stereotaxic device, a mechanical positioning system used in surgery. The two-dimensional MR images were reconstructed to form the three-dimensional volume shown, with skin and part of the brain cut away to reveal the tumor in yellow.

Craniofacial surgeon David Altobelli at Brigham is using 3-D images along with animation to simulate surgery. For example, surgery on a patient with an oversized lower jaw has been simulated to show Altobelli the precise cuts needed to normalize the jaw. These simulations are performed on a Sun Sparc workstation 370 with the addition of a custom 3-D image-processing accelerator board made by GE. The system's increased processing speed has been critical to the developments in Jolesz' group, Kikinis said.

Computer-aided surgery

Chicago radiologist David Levin and collaborators are experimenting with an interactive stereotaxic device for transferring computer-rehearsed surgical incision contours to the patient's body before an operation. Until now, surgeons have used the 3-D images only qualitatively to prepare for surgery. Levin said a new era of computer-aided surgery is in the offing.

Radiologist S. James Zinreich of Johns Hopkins Medical Institutions, Baltimore, Md., is experimenting with a robotic arm to position surgical instruments according to coordinates derived from MR images. Researchers William Bargar and Hap Paul at the University of California–Davis have successfully implanted an artificial hip in a dog using a robot arm dubbed Robodoc to carve out the opening based on data from an image. Experts believe that robots will only be able to support surgeons, not conduct operations independently; one reason is that the positioning accuracy of the robot and the MR image may not be good enough for many procedures.

Automated surgery is an offshoot of stereotaxic surgery, in which instruments are precisely positioned by using a mechanical reference system. Stereotaxic devices are typically used today

New techniques are becoming available to make a quantitative diagnosis of the flow of blood to the heart without invasive and sometimes life-threatening angiography. In angiography, a catheter is threaded up into a heart vessel and a dye injected. Since this diagnostic procedure has rather high morbidity and mortality rates, most cardiologists use it only as a last resort. Yet it remains the "gold standard" for diagnosing and quantifying coronary artery stenosis (constriction). Recent advances in hardware and reconstruction algorithms should make it possible for coronary blood flow to be quantitatively measured by magnetic resonance imaging techniques. Such a procedure is currently being explored at the Swiss Federal Institute of Technology in Zurich and at other locations. If it proves reliable and verifiable, the technique would greatly reduce the need for angiography.

In my field of rehabilitation engineering, we can make crude attempts in the laboratory to have "the blind see, the lame walk, the deaf hear, and the mute speak" (with apologies to Luke 4:16). Yet our efforts pale in comparison to the abilities of a neurologically intact individual. Still, one commercialized rehabilitation technology does promise its users a greatly enhanced quality of life. Cochlear implants can return some hearing to those who have suffered damage to the ear's cochlea. Essentially a transducer, the cochlea is tonotopic; that is, certain sound frequencies best excite certain areas, so that high frequencies are registered by regions near the eardrum, and the lowest frequencies, by those farther into the cochlea. The implants directly stimulate the appropriate set of nerves coming from the cochlea.

While multiple cochlear electrode arrays (such as Cochlear Corp.'s 22-channel array) have been in use for a few years, the primary stumbling block has been the development of spatial stimulus "codes" that compress speech into the best pattern for activating selected electrodes. If these codes can be better adapted to individual pathology, then many more patients might benefit from these implants.

One major hurdle remains. With arguments now occurring on the appropriate use, cost, and rationing of high-technology equipment to save or prolong life, the cost of a technology that "only" improves the quality of life can be questioned. If a technically sophisticated device that significantly enhances the quality of life of the end user is too costly, it would help only select individuals rather than all who need it. The question of cost vs. benefit of quality-of-life devices will continue to be debated by medical ethicists, governments, and insurance companies.

Charles J. Robinson (F) received a D.Sc. in electrical engineering from Washington University in St. Louis, Mo., an M.S. from Columbus-based Ohio State University, and a B.S. in engineering science from the College of Steubenville, Ohio. Robinson is the associate director of the Veterans Administration Rehabilitation R&D Center at Hines, Ill., near Chicago, and is a professor of neurology at Loyola University's School of Medicine. He lectures extensively on rehabilitation engineering and neurophysiology, with particular emphasis on spinal cord injury. He currently serves as president of the 7000-member IEEE Engineering in Medicine and Biology Society.

for biopsies and the electrocution of tiny portions of brain tissue for conditions like epilepsy. A CT or MR image is taken with the patient locked into the stereotaxic device, and then various instruments are attached to it and directed to points in the brain as determined by coordinates on the image.

Researchers have now begun to apply real-time imaging with stereotaxic surgery to get constant feedback on the progress of the operation. Jolesz and co-workers are investigating its use in laser surgery for brain tumor removal. The stereotaxic setup would direct the laser beam through an optical fiber at the tumor to kill the cancer cells. Thanks to echo-planar diffusion imaging, a recently developed MRI acquisition technique, the physician can track the diffusion of heat and stop the therapy before it harms surrounding normal tissue. The echo-planar technique measures the diffusion coefficient of tissues and then calculates temperature changes based on it.

Echo-planar imaging, developed by a number of manufacturers and researchers, offers the promise of real-time imaging because images can be acquired in only 60 milliseconds. But because the technique involves extensive modifications to existing MRI machines, other fast techniques with acquisition times less than 1 second have been developed. Siemens AG in Munich has developed turboflash, and General Electric Co., Fairfield, Conn., has developed fast SPGR and fast spin-echo—all of which require primarily software modifications. These methods perform complete scans in only a few minutes.

Jolesz' group, with the help of GE, is investigating MRI modifications that will allow the laser surgery to take place inside the scanner. (For portions of the procedure, such as inserting the needle through which the optical fiber is threaded, the patient would be partially removed from the unit.) Kikinis estimated the entire procedure would take 1–2 hours at first, but less later on with experience.

A variation on MRI, magnetic resonance spectroscopy (MRS), surprised the medical community with evidence from a Johns Hopkins study (done in collaboration with the GE R&D Center in Schenectady, N.Y.) showing it could accurately diagnose coronary artery disease. MRS has been investigated by researchers for more than a decade, but has found no useful clinical application until now. Whereas MRI detects hydrogen atoms to provide physical images of the body, MRS, which can be added to existing high-field MRI machines by changing software and detector coils, detects phosphorus and other elements and so monitors changes in tissue chemistry. Using the technique, the researchers found that the level of phosphates in heart tissue dropped during exercise with ■ hand grip only when the patient had poor blood supply to the heart, usually caused by clogged arteries.

Researchers are planning to compare MRS with the most common diagnosis method, an electrocardiogram taken while the patient runs on a treadmill. MRS may be more suitable for seriously ill or older patients for whom the treadmill is too strenuous, said GE laboratory manager Kirby Vosburgh. MRS might also be used to monitor angioplasty treatment, in which plaque is cleared from blood vessels by attaching balloons, mechanical cutters, lasers, or ultrasound devices to the end of a catheter.

Ultrasound in the bloodstream

Ultrasound imaging has been around for a while, but recent advances in sensor technology and its low costs compared to CT and MRI have opened up new applications for it. Particularly attractive is its use in imaging blood flow since the traditional method, X-ray angiography, requires injecting ■ radio-opaque iodine dye into the blood vessels through ■ catheter, a process that can be painful. Angiography is used to image defective heart valves, atherosclerotic plaque, or lesions in the blood vessels. The only other alternative, the recently developed MR angiography, is also noninvasive, but is much more expensive than ultrasonic color Doppler.

When first developed ■ few years ago, color Doppler could be applied only in cardiology, but today new sensors can pick up the slower blood flow in tissue-encased peripheral vessels. The technique directs ultrasound waves at blood vessels through the skin and detects the return frequency, which varies with blood velocity. One benefit of looking at peripheral vessels is that they indicate the success of organ transplants.

Last year, Acuson Corp., Mountain View, Calif., introduced an ultrasound device containing small vector-array sensors that have a wider field of view and can operate at two frequencies; the low frequency penetrates deeper beneath the skin, but the high frequency gives higher resolution. To get closer to the vessels or organs of interest, manufacturers are beginning to design probes that can be inserted into body cavities or swallowed.

Even smaller sensors—so small they can be inserted into blood vessels on catheters—are in the works. These sensors could be used not only for diagnosis, but as "eyes" for the physician during angioplasty. Companies producing these sensors include Diasonics Inc., Milpitas, Calif.; Endosonics Corp., Pleasanton, Calif.; Cardiovascular Imaging Systems Inc., Sunnyvale, Calif.; and Intertherapy Inc., Costa Mesa, Calif.

Interest in biomagnetic imaging continued to grow as the Japanese Government's Ministry of International Trade and Industry (MITI) formed a $44 million consortium with nine Japanese companies to develop a system for sensing the tiny magnetic fields emanating from the brain. These fields give a reading of the currents flowing in the brain, and consequently ■ biomagnetometer is ■ noninvasive indicator of localized brain function. It has been most successfully used to locate epileptic foci so that ■ minimum of brain tissue is removed in epileptics who must be treated surgically. It can also identify abnormal brain regions in schizophrenics and Alzheimers patients, but researchers hope to find applications in which it can affect treatment outcome. Areas of particular promise are diagnosing heart conditions and identifying regions of hearing loss to help in the design of hearing aids and cochlear implants.

Biomagnetic Technologies, San Diego, Calif., after receiving Food and Drug Administration (FDA) approval for its $2.2 million 37-channel Magnes biomagnetometer, went into full production, delivering units to University Hospitals and National Laboratory in Tokyo. Siemens also installed a 37-channel unit called the Krenikon at the University of Nuremburg but has not yet begun large-scale production.

Lithotripsy trips up

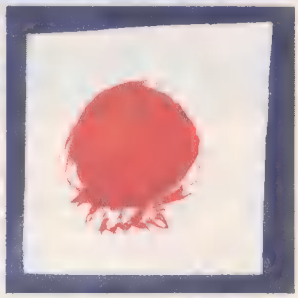
Gallstone lithotripsy received another setback when ■ U.S. study of 600 patients found that it had limited success. In 1989, the FDA in Rockville, Md., declined to approve two companies' lithotripters for gallstone treatment because of insufficient evidence of efficacy. Researchers led by Leslie J. Schoenfield at Cedars-Sinai Medical Center in Los Angeles reported that the shock-wave treatment eliminated the stones in only 47 percent of the patients. Of those patients taking ursodiol, ■ drug that prevents stone buildup after lithotripsy, only 21 percent were free of stones after six months, vs. 9 percent who took ■ placebo.

Removal of the gallbladder is a more effective treatment for gallstones than lithotripsy, physicians have found, and a recently developed laparoscopic method greatly simplifies gallbladder removal. With the help of a miniature television camera to guide the way, the organ can be removed through a tube inserted in ■ tiny incision in the abdomen. Patients recover in ■ few days to a week, compared to the 1-2 months for traditional surgery.◆

HIGHLIGHTS

Success: Research showed that magnetic resonance spectroscopy can detect coronary heart disease—possibly the first clinical application of the diagnostic technique.
Shortfall: The limited effectiveness of gallstone lithotripsy was further demonstrated in a study of 600 patients.
Notable: The use of volume imaging grew as an aid to stereotaxic surgery for precise positioning of instruments during brain surgery.
Newsmaker: U.S. Congress, which passed medical device law amendments that stiffened reporting requirements for defects in and adverse effects of medical devices.

THE SPECIALTIES



Neural networks proposed for diverse applications
A decision-technology concept improves budgeting
Curriculum revision gets high priority in education
Better interchange of integrated documents needed

Neural networks are slow to learn. . .cybernetics can boost competitiveness. . .the future engineer's education must encompass more topics in a more cohesive manner. . .the ability to transfer documents integrating test and graphics among different software packages needs developing. These comments on some of the more specialized branches of electrical engineering come from reports given to us by spokesmen from the IEEE Council on Neural Networks, the IEEE Systems, Man, and Cybernetics Society, the IEEE Education Society, and the IEEE Professional Communication Society.

Artificial neural networks remain the most exciting topic in the field of computational sciences, maintained Robert J. Marks II, president of the IEEE Council on Neural Networks. Meanwhile, however, they "are still seeking an application identity," he said. "Currently, the bulk of interest is being focused on artificial neural networks as classification and regression machines trained by example. Such networks have been proposed and preliminarily applied in fields as diverse as electric power load forecasting, medical diagnosis, mortgage brokering, explosives detection, speech recognition, remote sensing, and racehorse handicapping." The short-term success of the networks will be determined by their performance relative to other cutting-edge techniques and to more conventional approaches, he said, adding that in recent studies "in most cases, the artificial neural network has performed quite well."

But although the "modular and parallel structure and, in some cases, the highly fault-tolerant characteristics of artificial neural network architectures remain quite attractive," Marks cited some problems. "The most widely used artificial neural networks, for example, don't scale well. They typically yield a diminishing performance return as the size of the net grows," he observed. "Possible solutions include modularization or a more general algorithmic breakthrough." As for their current use as classification and regression machines, he pointed up significant training problems. "Current popular training procedures, for example, remain painfully slow and many require floating-point precision, prohibiting analog implementation," he said.

Better budgeting with TAPS

Madan G. Singh, vice president for publications, IEEE Society on Systems, Man, and Cybernetics, told us that a number of recent decision technology concepts and products are being used to enhance companies' competitiveness.

One example Singh told us about is Targeting and Allocation of Promotional Spend (TAPS). It brings together ideas from systems engineering, computer science, cognitive science, marketing, and mathematics, to produce a practical computer-based aid to budget allocation. Singh gave us this further explanation:

"TAPS follows a three-stage process. In stage 1, the judgments of a group of managers in response to a series of 'what if' expenditure scenarios generated by TAPS are captured. In stage 2, the expert knowledge base is used with mathematical optimization routines within TAPS to build up individual campaign models and a model of the total budget allocation across all campaigns. Stage 3 is one of exploration, which can provide answers to such questions as: how can sales be increased from the same budget? How, if the budget is increased or decreased, can it be allocated across different products and media types, to maximum effect? How are tradeoffs made between sales and image?"

Ronald K. Jurgen Senior Editor

Curriculum revision

Chalmers F. Sechrist Jr., vice president (1990) of the IEEE Education Society, told us that, at the present time, most attention is focused on restructuring the curriculum of the first two years of college. He predicted a major restructuring, updating, and modernizing of the undergraduate engineering core at a number of institutions during the 1990s because engineers of the 21st century will be expected to solve a broader and more complex set of problems and to accept more leadership positions in industry and government.

Other trends he foresaw include:

- Integration of mathematics, chemistry, physics, and some engineering courses in order to improve the connections between present courses and those taken previously.
- Integration of more computing, design, and oral and written communications into the curriculum.
- More emphasis on global awareness, improving the quality of life, international experiences, business, management skills, and the importance of engineering education.
- More exposure to nontechnical subjects such as ethics, safety, economics, and the impact of technology on society.
- Implementation of new instructional and learning methods using technology-based approaches.
- More emphasis on interactive methods in which students work together in interdisciplinary teams to learn cooperatively and to solve complex engineering design problems.

Integrated-document interchange needed

A major impediment to universal adoption of Wysiwyg (what-you-see-is-what-you-get) publishing and word-processing systems is the poor interchangeability of integrated documents among different platforms, said David L. McKown, member of the administrative committee and chair of the Ad Hoc Committee on New Communication Technology, IEEE Professional Communication Society. He explained why this is so:

"While several vendors now sell software that integrates text and graphics, and several of those offer that software on many hardware operating-system platforms, the ability to transfer integrated documents intact from one software package to another generally does not exist. This means that, although a user of WordPerfect on an MS-DOS platform can share integrated documents with a user of WordPerfect on a VAX, that same user cannot share integrated documents with a Microsoft Word user on any platform. The path to interchange involves separately converting the text and graphics into file formats that can be read by the other system, importing them separately, and then reintegrating the document."

Still, before this can become a useful reality, McKown said, improvements in data storage capacity and speed and processing power will be necessary.

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BUSINESS ROUNDUP

Among multinational corporations, IBM Corp., Matsushita Electric Industrial Co., and NEC Corp. top the list in electronics sales worldwide. The semiconductor sales champion is NEC of Japan, which has 9.9 percent of the world market. Having captured 11 percent of the telecommunications market, the Netherlands-based Alcatel NV leads everyone else in this field. And market shares of more than 58 percent in mainframes and more than 15 percent in personal computers make IBM king of both areas.

Hardly surprisingly, the hottest electronics production area is data processing, in which the United States, at US $83 billion, far surpasses both Japan and Europe.

In consumer electronics, a dramatic picture unveils: companies headquartered in Japan filled the needs of virtually the entire Japanese market, unlike the United States and Europe.

A barometer of global electrotechnology activities, the number of patents in electrical classes issued in the United States in 1989 was close to 24 000, about 50 percent more than in 1985.

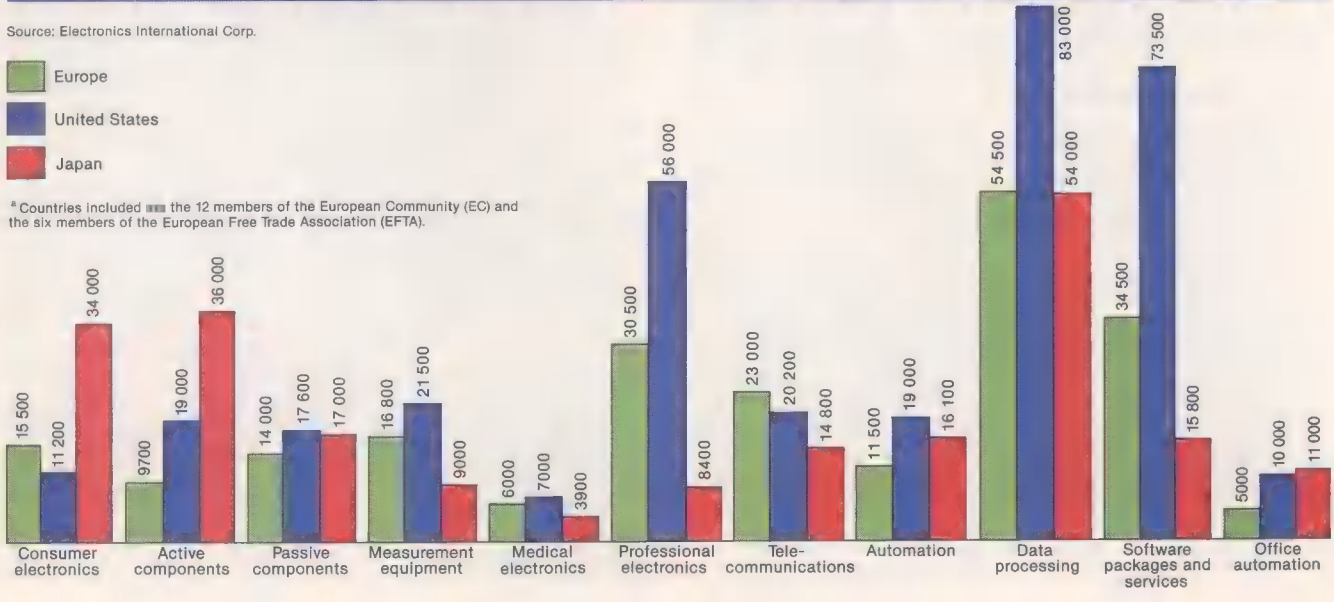
Gadi Kaplan
Senior Technical Editor

The world's top 20 electronics companies

Company	Country	Electronics sales, in millions of U.S. dollars	Electronics as percent of total sales[a]	Sales per employee in thousands of U.S. dollars	R&D as a percentage of electronics sales	Results to:
IBM Corp.	U.S.	62 710	100	163.65	10.89	12/89
Matsushita Electric Industrial Co.	Japan	31 319	72	219.36	5.76	3/90
NEC Corp.	Japan	24 957	100	217.77	7.17	3/90
Toshiba Corp.	Japan	22 674	71	224.89	6.03	3/90
Hitachi Corp.	Japan	22 055	43	176.38	6.06	3/90
Philips NV	N'lands	21 594	80	88.56	7.96	12/89
Siemens AG	W.Germany	19 825	61	89.04	11.29	9/89
Fujitsu Ltd.	Japan	18 477	100	160.65	11.73	3/90
Sony Corp.	Japan	16 904	81	218.29	5.74	3/90
General Motors Corp.	U.S.	16 880	14	158.98	0.00	12/89
AT&T Co.	U.S.	16 612	46	N.A.	7.30	12/89
CGE	France	13 307	59	107.25	7.51	12/89
Digital Equipment Corp.	U.S.	12 943	100	104.38	12.47	6/90
General Electric Co.	U.S.	12 369	29	146.06	9.22	12/89
Mitsubishi Electric Corp.	Japan	11 862	55	242.03	4.88	3/90
Xerox Corp.	U.S.	11 602	100[b]	117.19	6.97	12/89
Thomson-CSF	France	11 175	93	120.16	5.45	12/89
Unisys Corp.	U.S.	10 097	100	122.68	7.74	12/89
Motorola Inc.	U.S.	9 620	100	92.50	8.15	12/89
Canon Inc.	Japan	9 593	98	220.48	5.60	12/89

Source: Elsevier Advanced Technology, Oxford, England
a The electronics-only sales have been converted at the 1987 average exchange rate.
b Equipment sales only; if financial and insurance services are included, the percentage is 66 percent.
N.A. = not available.

Estimated 1990 electronics production in Europe[a], the United States, and Japan, in U.S. dollar millions



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Worldwide market share rankings

Semiconductors

Rank	Company and country	Market share
1	NEC Corp., Japan	8.8%
2	Toshiba Corp., Japan	8.6%
3	Hitachi Ltd., Japan	6.9%
4	Motorola Inc., U.S.	5.8%
5	Fujitsu Ltd., Japan	5.2%
6	Texas Instruments Inc., U.S.	4.9%
7	Mitsubishi Electric Corp., Japan	4.5%
8	Intel Corp., U.S.	4.2%
9	Matsushita Electric Industrial Co., Japan	3.3%
10	Philips NV, the Netherlands	3.0%
	Others	44.8%

Telecommunications equipment

Rank	Company and country	Market share
1	Alcatel NV, the Netherlands	11.0%
2	AT&T Co., U.S.	10.8%
3	BCE Inc., Canada	6.8%
4	Siemens AG, Germany	6.6%
5	NEC Corp., Japan	6.0%
6	L. M. Ericsson, Sweden	4.1%
7	British Telecom PLC, UK	2.9%
8	GTE Corp., U.S.	2.6%
9	Fujitsu Ltd., Japan	2.4%
10	NTT Corp., Japan	2.0%
	Others	44.7%

Personal computers

Rank	Company and country	Market share*
1	IBM Corp., U.S.	15.06%
2	Apple Computer Inc., U.S.	9.38%
3	NEC Corp., Japan	6.69%
4	Compaq Computer Corp., Japan	5.99%
5	Toshiba Corp., Japan	3.19%
	Others	40.31%

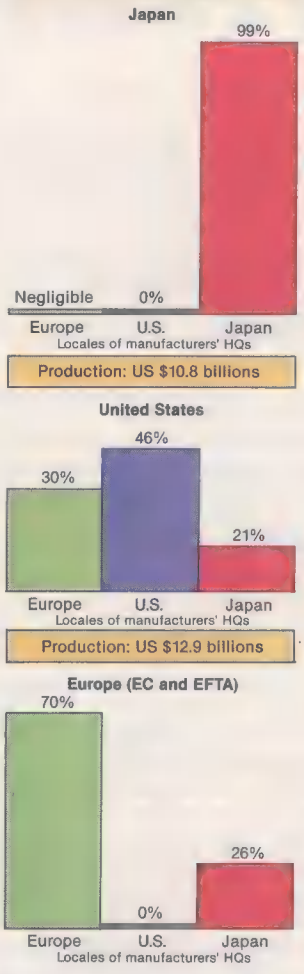
* By if-sold value.

Mainframe computers

Rank	Company and country	Market share
1	IBM Corp., U.S.	58.13%
2	Unisys Corp., U.S.	6.94%
3	NEC Corp., Japan	5.57%
4	Groupe Bull, France	5.48%
5	Fujitsu Ltd., Japan	5.26%
	Others	18.63%

Source: Dataquest Inc. (four tables)

Domestic consumer electronics production, worlds in central



Source: Electronics International Corp.

Top 10 countries granted electrical U.S. patents for 1963–89

	Number of patents			
	1980	1985	1989	1963–89 total
Total	11 910	15 724	23 638	218 134
U.S. origin	6901	8007	10 844	117 555
Non-U.S. origin	5009	7717	12 794	100 579
Japan	2290	4302	7904	52 559
West Germany	881	1084	1454	15 235
France	391	561	766	7403
United Kingdom	391	453	721	7214
The Netherlands	204	263	376	3506
Canada	144	244	347	3065
Switzerland	203	205	208	2909
Italy	101	113	188	1747
Sweden	96	121	147	1676
USSR	110	31	34	789

Source: U.S. Patent and Trademark Office

Top 10 companies granted electrical U.S. patents for 1969–89

	Number of patents			
Company and country	1980	1985	1989	Total for 1969–89
IBM Corp., U.S.	247	349	417	4893
Hitachi Ltd., Japan	223	380	670	4861
U.S. Philips Corp., U.S.	228	345	559	4764
General Electric Co., U.S.	276	298	332	4629
Toshiba Corp., Japan	177	465	685	4286
Siemens AG, West Germany	248	263	395	4221
RCA Corp., U.S.	307	331	1	4195
AT&T Co., U.S.	226	328	238	3852
Canon Inc., Japan	102	304	605	3723
Westinghouse Electric Corp., U.S.	229	191	167	3151

Source: U.S. Patent and Trademark Office

The United States Patent and Trademark Office has more than 60 different categories in its "Electrical Class" patents, including conductors and insulators, circuit makers and breakers, electric heating, electrical transmission or interconnection systems, electrical generator or motor structures, electric lamps and discharge devices, power supply or regulation systems, measuring and testing, demodulators and detectors, amplifiers, oscillators, modulators, [redacted] transmission lines and networks, tuners, coded data generation or conversion, communications, computers and data-processing systems.

TO PROBE FURTHER

HUBBLE'S TROUBLES—For a description of the Hubble Space Telescope's promise, see "Next-generation spacecraft control," by Trudy E. Bell, *IEEE Spectrum*, December 1989, pp. 34–38. For reports on its engineering troubles as they emerged, see THE INSTITUTE: "Antenna pair tied to be fit," July 1990; "Space telescope probe focuses on fuzzy optics," September 1990; and "Hubble's promise undimmed," December 1990.

PERSONAL COMPUTERS, WORKSTATIONS—The Third IEEE Conference on Computer Workstations: Accomplishments and Challenges will be held May 15–17 at the Sea Crest Resort, Falmouth, Mass. Contact the IEEE Computer Society, Conference Services, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013.

SOFTWARE—The 1991 IEEE Software Engineering Standard Application Workshop will be held May 20–24 in San Diego, Calif. Contact the IEEE Computer Society's Conference Services at the above address.

MINIS, MAINFRAMES—Recent material on the computer industry includes the section on European "Microelectronics and computers," in the June 1990 special issue of *Spectrum*. Coverage in THE INSTITUTE included "Japanese boost speed of supercomputers" and "Big computers debut," both in the November issue; "Entry-level supercomputer pits Cray against Convex," July; and "Supercomputing '90: reports of the demise of VLIW have been greatly exaggerated," in the current edition.

TELECOMMUNICATIONS—For more on code-division multiple access, see "Spread spectrum goes commercial," by Donald L. Schilling, Raymond L. Pickholtz, and Laurence B. Milstein, *Spectrum*, August 1990, pp. 40–45. For the same issue, S. Joseph Campanella wrote "Communications satellites: orbiting into the '90s," pp. 49–52, and Trudy E. Bell described soliton communication in "Light that acts like 'natural bits'," pp. 56–57.

DATA COMMUNICATIONS—A seminar, "Routers, Bridges, and Gateways: The How-To of Connectivity," will be held Jan. 16–17 at the Madison Tower Hotel in New York City. Registration is US $895. Contact the Bodie Institute, 55 Main St., Madison, N.J. 07940; 201-593-0400.

SOLID STATE—A number of upcoming IEEE meetings should provide valuable solid-state information. Among them are:

▪ International Solid-State Circuits Conference, San Francisco Hilton Hotel, Feb. 13–15. Contact Diane Suiters, Courtesy Associates, 655 15th St., N.W., Suite 300, Washington, D.C. 20005; 202-347-5900.

• Custom IC Conference, Town & Country Hotel, San Diego, Calif., May 13–16. Contact Laura Morihara, 47-344 Waihee Rd., Kaneohe, Oahu, Hawaii 96744; 808-239-4790.

• VLSI Technology Symposium, Oiso Prince Hotel, Kanagawa, Japan, May 28–30. Contact: Dirk Bartelink, Hewlett-Packard Co., 3500 Deer Creek Rd., Palo Alto, Calif. 94304; 415-857-5364.

TEST AND MEASUREMENT—The boundary-scan test methodology is explained by two principal authors of the IEEE 1149.1 standard, Rod E. Tulloss and Colin M. Maunder, in an IEEE Computer Society Press book called *The Test Access Port and Boundary-Scan Architecture*. Contact IEEE Computer Society Publications Office, 10662 Los Vaqueros Circle, Box 3014, Los Alamitos, Calif. 90720-1264; 1-800-272-6657. To purchase the standard, ask for IEEE Std 1149.1-1990 (product No. SH-13144) from the IEEE Service Center.

INDUSTRIAL ELECTRONICS—IECON '91, the 17th annual conference of the IEEE Industrial Electronics Society, will be held Oct. 28–Nov. 1 at the International Conference Center, Kobe, Japan. Contact the Society of Instrument and Control Engineers, 1-35-28-303 Hong, Bunkyo-ku, Tokyo, 113 Japan; 81-3-814-4699.

POWER, ENERGY—*The Financial Times* is a good source of information on Europe's turbulent electric utilities and related industries, such as nuclear power. Published in London, at One Southwark Bridge, the paper is available every day in many large cities outside the United Kingdom.

CONSUMER ELECTRONICS—The latest consumer electronics products are exhibited by manufacturers twice a year at the International Winter and Summer Consumer Electronics Shows: this year's summer show is in Chicago, June 1–4; the winter show was held in Las Vegas, Jan. 10–13. Contact the Consumer Electronics Group, Electronic Industries Association, 2001 Pennsylvania Ave., N.W., Washington, D.C. 20006-1813; 202-457-4900.

TRANSPORTATION—The IEEE Vehicular Technology Conference covers primarily developments in land mobile radio but also automotive electronics and light rail. The 1991 conference will be held May 19–22 in Maryland Heights, near St. Louis, Mo. Contact J.W. Underdown, 58 Judy Dr., St. Charles, Mo. 63301; 314-946-9980. The conference will overlap with the Joint IEEE/ASME Railroad Conference at the same location, May 20–23. Contact Doug Campion at 314-982-1517.

AEROSPACE, MILITARY—Wincon '91, the 1991 IEEE Winter Convention on Aerospace and Electronic Systems, will be held Feb. 26–28 in Los Angeles. Contact Julie Mikovits, SAIC, 21151 Western Ave., Torrance, Calif. 90501-1724; 213-781-8525. Naecon '91, the 1991 National Aerospace and Electronics Conference, will be held May 20–24 at the Dayton Convention Center, Ohio. Contact Sue Brown, ASD/ENES, Wright-Patterson AFB, Ohio 45433-6503; 513-255-6281.

MEDICAL ELECTRONICS—The 13th Annual International Conference of the IEEE Engineering in Medicine and Biology Society will be held Oct. 31–Nov. 3 at the Hilton Hotel at Walt Disney World, Lake Buena Vista, Fla. Contact Joachim H. Nagel, Dept. of Biomedical Engineering, University of Miami, Box 248294, Coral Gables, Fla. 33124; 305-284-2442.

THE SPECIALTIES—The 1991 International Joint Conference on Neural Networks will be held at the Sheraton Seattle Hotel, Seattle, Wash., July 8–14. Contact Diana Nielsen, University of Washington, 5001 25th St. N.E., GH-22, Seattle, Wash. 98195; 206-543-0888.

BUSINESS ROUNDUP—Three excellent sources of business statistics on the world electronics industry are:

• Elsevier Advanced Technology, Mayfield House, 256 Banbury Rd., Oxford, England OX 2 7DH; (44+865) 512 242.

• Dataquest Inc., 1290 Ridder Park Dr., San Jose, Calif. 95131-2398; 408-437-8000.

▪ Electronics International Corp., 101 West 55th St., New York, N.Y. 10019; 212-307-1960.

For information on IEEE publications, contact the IEEE Service Center, 445 Hoes Lane, Piscataway, N.J. 08855-1331; 201-981-0027. ✦

ACKNOWLEDGMENTS

This issue would not have been possible without the help of the many expert technical reviewers we call upon to critique the material planned for the issue before it is released for publication.

The pictures of the experts that appear with each major article in this issue were drawn by Barry Ross, Northampton, Mass.

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1991 IEEE guide for authors

If you wish to publish an article in an IEEE journal, transactions, or magazine, or submit a proposal for a book, send the manuscript to the appropriate editor, using the list below. If you are unsure of the appropriate publication, send your manuscript to Associate General Manager, Programs, IEEE, 345 E. 47th St., New York, N.Y. 10017.

If you require general guidance in IEEE style, send for *Information for IEEE Transactions and Journal Authors*, available at the above address. Specific authors' information may also be found in many of the journals themselves, usually on the back or inside back cover. All guides are free. They must be requested by their correct titles to avoid confusion.

In the listings below, frequency of publication is noted in parentheses.

Special note to *IEEE Spectrum* authors

IEEE Spectrum has the largest international circulation among magazines in the electrical/electronics field; it affords the primary link between the IEEE and all its members. *Spectrum*'s objectives are to provide interesting and useful information on a broad range of technical and career-oriented topics and to increase the awareness among readers of fields outside their immediate specialties. The *Spectrum* staff works closely with authors to help them revise their manuscripts, drastically when necessary, to gain high readability and utility to the reader.

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Managing Editor, Proceedings of the IEEE, 345 E. 47th St., New York, N.Y. 10017
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IEEE TRANSACTIONS, JOURNALS, AND MAGAZINES

These publications of IEEE Societies provide the means by which the member keeps abreast of the advances in a specific field of specialization. Their mission is to record and disseminate new scientific and technical information for both present and future members of the profession.

Aerospace and Electronic Systems, IEEE Trans.
Equipment, procedures, and techniques applicable to the organization, installation, and operation of functional systems designed to meet high-performance requirements of earth and space systems. (6)
Jack R. Harris, 20400 Highland Hall Dr., Gaithersburg, Md. 20879 301-251-4810

Aerospace and Electronic Systems Magazine
Articles dealing with functional systems for space, air, ocean, or ground environments and systems interactions. Includes Society news, book reviews, and patent announcements. (12)
H. Warren Cooper, 7211 Windsor Lane, Hyattsville, Md. 20782 301-927-7681

Antennas and Propagation, IEEE Trans.
Theoretical and experimental advances in antennas, including design and development, and in the propagation of electromagnetic waves, including scattering, diffraction, and interaction with continuous media; and applications pertaining to antennas and propagation, such as remote sensing, applied optics, and millimeter and submillimeter wave techniques. (12)
Robert E. McIntosh, Dept. of ECE, University of Massachusetts, Amherst, Mass. 01003 413-545-0709

Antennas and Propagation Magazine
Covers all areas relating to antenna theory, design and practice; propagation, both theory and effects; and a broad range of general interest topics including basic electromagnetics, computational and numerical techniques, personal computers for EEs, scattering and diffraction, radar and radar cross sections. (6)
W. Ross Stone, IRT Corp., 1446 Vista Claridad, La Jolla, Calif. 92037 619-592-2094

Applied Superconductivity, IEEE Trans.
Sponsored by the IEEE Superconductivity Committee
Materials and their application to electronics and power systems, where superconductivity is central to the work. Materials papers are directed toward applications so that their contents are of great interest to the applications community. Includes a technical notes section dedicated to short correspondences whose rapid publication is considered important to the development of the field. (4)
Theodore Van Duzer, Dept. of EECS, University of California, Berkeley, Calif. 94720 415-642-3306

Automatic Control, IEEE Trans.
The theory, design, and application of control systems: real-time control, optimal control, adaptive and stochastic control, estimation and identification, linear systems, system modeling, and applications of physical, economic and social systems. (12)
N.H. McClamroch, Department of Aerospace Engineering, University of Michigan, Ann Arbor, Mich. 48109 313-763-9304

Biomedical Engineering, IEEE Trans.
Basic and applied papers dealing with biomedical engineering and applied biophysics and ranging from practical/clinical applications through experimental science and technological development to formalized mathematical theory. (12)
Dr. Michael R. Neuman, Obstetrics & Gynecology, Cleveland Metro General Hospital, 3395 Scranton Rd., Cleveland, Ohio 44109 216-459-5095

Broadcasting, IEEE Trans.
Broadcast technology, including the production, distribution, transmission, and propagation aspects of broadcasting. (4)
Phil Rubin, Rubin, Bednarek & Associates, 1350 Connecticut Ave., Suite 610, Washington, D.C. 20036 202-296-9380

Circuits and Devices Magazine
Applications-oriented papers and tutorials, up-to-date information on new products, inventions, new books, conference schedules, and other useful information on VLSI and technology, computer-aided design, semiconductor processes, quantum electronics, and digital and analog circuits. (6)
Ronald W. Waynant, Food and Drug Administration, Center for Devices and Radiological Health (CDRD), Electro-Optics Branch, HF2-134, 5600 Fishers Lane, Rockville, Md. 20857 301-443-2965

Circuits and Systems, IEEE Trans.
Design and theory of operations of circuits for use in radio and electronic equipment. (12)
Dr. R. Liu, Dept. of ECE, University of Notre Dame, Notre Dame, Ind. 46556 219-239-6228

Circuits and Systems for Video Technology, IEEE Trans.
Sponsored by the IEEE Circuits and Systems Society
Emphasis on video processing algorithms, real-time implementation, VLSI architecture and technology, and related topics focused on, but not limited to video A/D and D/A; video compression techniques and signal processing; multidimensional filters and transformers, high-speed real-time circuits; multiprocessor systems—hardware and software; and VLSI architecture and implementation for video technology. (4)
Ming Liou, Bellcore, 331 Newman Springs Rd., Red Bank, N.J. 07701 201-758-2949

Communications, IEEE Trans.
All telecommunications including telephone, telegraphy, facsimile, and point-to-point television, by electromagnetic propagation, including radio; wire; aerial, underground, coaxial, and submarine cables; waveguides, communication satellites, and lasers; in marine, aeronautical, space, and fixed station services; repeaters, radio relaying, signal storage, and regeneration; telecommunication error detection and correction; multiplexing and carrier techniques; communication switching systems; data communications; and communication theory.(12)
Victor Lawrence, AT&T Bell Laboratories, Room 1P-246, 200 Laurel Ave., Middletown, N.J. 07748 201-957-3410

Communications Magazine
All areas of communications: conferences, short courses, standards, governmental regulations and legislation, book reviews, and special feature technical articles; Society news, including administration and elections. (12)
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Communications, Selected Areas in, IEEE J.
All telecommunications, including telephone, telegraphy, facsimile, and point-to-point television, by electromagnetic propagation, including radio; wire; aerial, underground, coaxial, and submarine cables; waveguides, communication satellites, and lasers; in marine, aeronautical, space, and fixed station services; repeaters, radio relaying, signal storage, and regeneration; telecommunication error detection and correction; multiplexing and carrier techniques; communication switching systems; data communications; and communication theory. (9)
William H. Tranter, Dept. of EE, University of Missouri, Rolla, Mo. 65401 314-341-4514

Components, Hybrids, and Manufacturing Technology, IEEE Trans.
Component parts, hybrid microelectronics, materials, packaging techniques, and manufacturing technology. (4)
Paul G. Slade, Westinghouse R&D, 1310 Beulah Rd., Pittsburgh, Pa. 15235-5098 412-256-1011

Computer-Aided Design of Integrated Circuits and Systems, IEEE Trans.
Methods, algorithms, and man-machine interfaces for physical and logical design, including: planning, synthesis, partitioning, modeling, simulation, layout, verification, testing, and documentation of integrated-circuit and systems designs of all complexities. Practical applications of aids resulting in producible analog, digital, optical, or microwave integrated circuits are emphasized. (12)
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Computer Applications in Power Magazine
Magazine devoted to computer applications to the design, operation, and control of power systems. Includes articles on transient network analysis, circuit evaluation, steady-state analysis, cable management systems, economics, and contingency analysis. (4)
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Computer Graphics and Applications Magazine
Computer graphics hardware and software, display technology, computational geometry, geometric data structures and databases, industrial applications, animation methodology, human factors for graphics, interactive graphics languages, graphic arts, graphics support of MIS, and distributed graphics techniques. (6)
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Computer Magazine
Survey and tutorial articles covering a broad range of computer hardware, software, and system design and application; special issues focus on such topics as VLSI design, software engineering, local area networks, computer communications, and computer architecture. Regular departments present new product announcements, book reviews, and professional calendar. (12)
Bruce D. Shriver, Vice President for Research, University of Southwestern Louisiana, Drawer 42730, Lafayette, La. 70504 318-231-6000

Computers, IEEE Trans.
All fields of computation, information processing, applications, and computer systems research and design. (12)
Ming T. Liu, Dept. of Computer & Information Science, Ohio State University, 2036 Neil Ave. Mall, Columbus, Ohio 43210 614-292-1837

Consumer Electronics, IEEE Trans.
The design and manufacture of consumer electronics products, components, and related activities, particularly those used for entertainment, leisure, and educational purposes. (4)
Wayne C. Luplow, Zenith Electronics Corp., 1000 Milwaukee Ave., Glenview, Ill. 60025 312-391-7873

Control Systems Magazine
Control system applications and experiences, design tools, conference programs, educational features, book reviews, and Society news items. Oriented toward practicing control system engineers.(7)
Herbert Rauch, Lockheed 92-20/254E, 3251 Hanover St., Palo Alto, Calif. 94304 415-424-2704

Design and Test of Computers Magazine
Covers methods, practical experience, research ideas, and commercial products that aid in the design and test of chips, assemblies, and systems —e.g., design automation, CAD workstations, design software, computer-aided test, test equipment, self-test, and design for testability. (4)
Sumit Dasgupta, IBM, E. Fishkill Bldg. 306, ZIP 3A1, Hopewell Junction, N.Y. 12533 914-894-0540

Education, IEEE Trans.
Educational methods, technology, and programs; history of technology; impact of evolving research on education. (4)
Prof. Frank Barnes, Dept. of Electrical and Computer Engineering, University of Colorado, Campus Box 425, Boulder, Colo. 80309-0425 303-492-5071

Electrical Insulation, IEEE Trans.
Electrical insulation common to the design and construction of components and equipment for use in electric and electronic circuits and distribution systems at all frequencies. (6)
Arend van Roggen, RD 2, Kennett Square, Pa. 19348 215-388-6909

Electrical Insulation Magazine
Compilation of articles and news that relate to insulation and dielectrics. Includes conference activities reporting and papers of general interest. (6)
J.A. Tanaka, University of Connecticut, Chemistry Dept./U-60, Room 151, 215 Glenbrook Rd., Storrs, Conn. 06269-3060 203-486-2443

Electromagnetic Compatibility, IEEE Trans.
EMC standards; measurement technology; undesired sources; cable/grounding; filters/shielding; equipment EMC; systems EMC; antennas and propagation; spectrum utilization; electromagnetic pulses; lightning; radiation hazards; and Walsh functions. (4)
Motohisa Kanda, Electromagnetic Fields Division, National Bureau of Standards, Boulder, Colo. 80303 303-497-5320

Electron Device Letters
Rapid publication of short communications on new results in the field of electron devices. Items are restricted to two pages and appear, on average, three months after receipt. (12)
John Brews, Dept. of Electrical and Computer Engineering, Room 230, Building 104, University of Arizona, Tucson, Ariz. 85721
602-621-8734

Electron Devices, IEEE Trans.
The theory, design, and performance of active electron and ion devices, solid-state devices, integrated electron devices, and energy sources. (12)
Renuka Jindal, AT&T Bell Labs, Room 2A-142, 600 Mountain Ave., Murray Hill, N.J. 07974
201-582-5775

Electronic Materials, IEEE J.
Applications of semiconductors, magnetic alloys, insulators, and optical and display materials.(12)
Theodore C. Harman, MIT Lincoln Laboratory, Lexington, Mass. 02173 617-981-4418

Energy Conversion, IEEE Trans.
Research, development, design, application, construction, installation, and operation of electric power generating facilities (along with their conventional, nuclear, or renewable sources) for the safe, reliable, and economic generation of electrical energy for general industrial, commercial, public, and domestic consumption. (4)
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908-562-3881

Engineering Management, IEEE Trans.
Management of technical functions such as research, development, and engineering in industry, government, university, and other settings. Emphasis is on studies carried on within an organization to help in decision making or policy formation for RD&E. (4)
Dundar F. Kocaoglu, Engineering Management Program, School of Engineering and Applied Science, Portland State University, Portland, Ore. 97207-0751 503-464-4660

Engineering Management Review
A reprint of selected papers relevant to engineering management. (4)
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714-633-9660

Engineering in Medicine and Biology Magazine
Contains general and technical short articles on current technologies and methods used in Biomedical and Clinical Engineering. Current news items, book reviews, patent descriptions, and a correspondence section are included. (4)
A.S. Wald, Dept. of Anesthesiology, Columbia-Presbyterian Medical Center, 630 W. 168th St., New York, N.Y. 10032 212-305-2164

Expert Magazine (Intelligent Systems and Their Applications)
Tutorial and survey articles on the current applications of intelligent systems, including databases, expert systems, and artificial intelligence. (6)
B. Chandrasekaran, Ohio State University, Computer and Information Sciences Dept., LAIR Building, CAE Room 228, 2036 Neil Ave., Columbus, Ohio 43210-1277

Geoscience and Remote Sensing, IEEE Trans.
Theory, concepts, and techniques of science and engineering as applied to sensing the earth, oceans, atmosphere, and space; and the processing, interpretation, and dissemination of this information. (6)
Richard Doviak, University of Oklahoma, Cooperative Institute for Mesoscale Meteorological Studies, 401 E. Boyd St., Norman, Okla. 73019
405-325-6021

Industrial Electronics, IEEE Trans.
The application of electronics and electrical sciences to the control, treatment, and measurement of industrial processes. (6)
Gerald Cook, Dept. of Electrical and Computer Engineering, George Mason University, 4400 University Dr., Fairfax, Va. 22030
703-323-2630

Industry Applications, IEEE Trans.
The development and application of electric systems, apparatus, devices, and controls to the processes and equipment of industry and commerce; the promotion of safe, reliable, and economic installations; the encouragement of energy conservation; and the creation of voluntary engineering standards and recommended practices. (6)
Edward A.E. Rich, 243 Juniper Dr., Schenectady, N.Y. 12306 518-372-9572

Information Theory, IEEE Trans.
The fundamental nature of the communication process; transmission and utilization of information; coding and decoding of digital and analog communication transmissions; study of random interference and information-bearing signals; and the development of information-theoretic techniques in diverse areas, including communication systems, detection systems, pattern recognition, learning, and automata. (6)
Bruce Hajek, Coordinated Science Laboratory, University of Illinois, 1101 W. Springfield Ave., Urbana, Ill. 61801 217-333-3605

Instrumentation and Measurement, IEEE Trans.
Measurements and instrumentation utilizing electrical and electronic techniques. (6)
Ed Richter, 7 Mohawk Rd., Acton, Mass. 01720
508-263-7256

Knowledge and Data Engineering, IEEE Trans.
Provides a forum to publish results on the research, design, and development of knowledge and data engineering methodologies, strategies, and systems as related to computer science, artificial intelligence, electrical engineering, computer engineering, and other appropriate fields. (4)
C.V. Ramamoorthy, Computer Science Division, University of California, Berkeley, Calif. 94720
415-642-4751

IEEE LCS: The Magazine of Lightwave Communication Systems
Covers all aspects of the use of lightwave technologies in communication systems and networking, focusing on systems, architectures, standards, and applications. Topics include coherent communications, broadband and photonic systems and applications, optical systems for TV transport and distribution, optical local to wide area networking, optical interconnects, optical undersea and terrestrial communication systems, and passive photonic network technologies. (4)
Larry L. Campbell, 9109 Jeffrey Rd., Great Falls, Va. 22066 703-759-4199

Lightwave Technology, J.
All aspects of optical guided-wave science, technology, and engineering in the areas of fiber and cable technologies; active and passive guided-wave componentry (light sources, detectors, repeaters, switches, fiber sensors, etc.); integrated optics and optoelectronics; systems and subsystems; new applications; and unique field trials. (12)
Donald Keck, Corning Glass Works, SP FR 29, Corning, N.Y. 14831 607-974-3095

Magnetics, IEEE Trans.
The fundamental development, design, and application of magnetic devices as well as magnetic materials and phenomena pertaining to engineering purposes. (6)
Carl E. Patton, Dept. of Physics, Colorado State University, Fort Collins, Colo. 80523
303-491-5083

Medical Imaging, IEEE Trans.
Imaging of body organs, usually in situ, rather than microscopic biological entities; the associated equipment and techniques, such as instrumentation systems, transducers, computing hardware, and software. (4)
A. Bertrand Brill, Dept. of Nuclear Medicine, University of Massachusetts Medical Center, 55 Lake Ave. N., Worcester, Mass. 01655
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Micro Magazine
Microprocessor technology; computer-aided design; system support software, interfacing techniques, chip design, and fabrication; personal computing; control hierarchies, architectures, applications and draft standards for hardware, software, and interconnections. (6)
Joseph Hootman, EE Dept., University of North Dakota, Box 7165, Grand Forks, N.D. 58202
701-777-4331

Microwave and Guided Wave, IEEE Letters
Offers short archival publication with minimal delay of original research relevant to microwave technology. (12)
Tatsuo Itoh, Dept. of Electrical and Computer Engineering, University of Texas, Austin, Texas 78712 512-471-1072

Microwave Theory and Techniques, IEEE Trans.
Microwave theory, techniques, and applications as they relate to components, devices, circuits, and systems involving the generation, transmission, and detection of microwaves. (12)
Stephen Maas, EE Dept., 56-125B Engineering V, UCLA, Los Angeles, Calif. 90024
213-206-1668

Network Magazine (The Magazine of Computer Communications)
Network protocols and architecture; protocol design and validation; communications software; network control, signaling, and management; network implementation (LAN, MAN, WAN); and micro-to-host communications. (6)
Warren S. Gifford, Bellcore, 331 Newman Springs Rd., Room 1C401, Red Bank, N.J. 07701
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Neural Networks, IEEE Trans.
Devoted to the science and technology of neural networks which disclose significant technical knowledge, exploratory developments, and applications of neural networks from biology to software to hardware. Emphasis is on artificial neural networks. Specific aspects include self-organizing systems,

neurobiological connections, network dynamics and architecture, speech recognition, electronic and photonic implementation, robotics and controls.(6).

Michael Roth, Johns Hopkins University Applied Physics Lab, Johns Hopkins Rd., Laurel, Md. 20723 301-792-6543

Nuclear Science, IEEE Trans.
Instrumentation, high-energy physics, reactor controls, and radiation effects, including environmental instrumentation, measurement, and monitoring; fusion technology; nuclear instruments and detectors; nuclear medical science; plasma science and applications; radiation effects; reactor instrumentation and control; particle acceleration science and technology; and computer applications in nuclear and plasma sciences. (6)

Dick A. Mack, 600 Lockwood Lane, Santa Cruz, Calif. 95066 408-438-0200

Oceanic Engineering, IEEE J.
Bayes procedures; buried-object detection; dielectric measurements; Doppler measurements; geomagnetism; sea floor; sea ice; sea measurements; sea surface electromagnetic scattering; seismology; sonar; acoustic tomography; underwater acoustics; and underwater radio communication. (4)

Frederick H. Fisher, Marine Physical Laboratory, Scripps Institution of Oceanography, University of California, La Jolla, Calif. 92093 619-534-1796

Parallel and Distributed Systems, IEEE Trans.
Devoted to hardware/software issues and applications studies specifically for parallel and/or distributed computing systems. Subject areas include parallel and distributed architectures including design, analysis and implementation of multiple processor systems, impact of VLSI on design; parallel and distributed software including languages and compilers, programming environments; parallel algorithms and applications; performance measurements, evaluation, and modeling. (4)

Tse-Yun Feng, Dept. of EE, Engineering East Building, Pennsylvania State University, University Park, Pa. 16802 814-863-1469

Pattern Analysis and Machine Intelligence, IEEE Trans.
Artificial intelligence; computer vision and image analysis; architectures; image processing; speech analysis; text processing; pattern recognition; and classification techniques. (12)

Anil Jain, Dept. of Computer Science, A-726 Wells Hall, Michigan State University, East Lansing, Mich. 48824 517-353-5150

Photonics Technology, IEEE Letters
Rapid publication of original research relevant to photonics technology. This expanding field emphasizes laser and electro-optic technology, laser physics and systems, applications, and photonic/lightwave components and applications. The journal offers short, archival publication with minimal delay. (12)

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Plasma Science, IEEE Trans.
Plasma science and engineering, including: magnetofluid dynamics and thermionics; plasma dynamics; gaseous electronics and arc technology; controlled thermonuclear fusion; electron, ion, and plasma sources; space plasmas; high-current relativistic electron beams; laser-plasma interactions; diagnostics; plasma chemistry and colloidal and solid-state plasmas. (6)

Steven J. Gitomer, Group X-1, Mail Stop E-531, Los Alamos National Lab, Box 1663, Los Alamos, N.M. 87545 505-667-5995

Power Delivery, IEEE Trans.
Research, development, design, application, construction, the installation and operation of apparatus, equipment, structures, materials, and systems for the safe, reliable, and economic delivery and control of electric energy for general industrial, commercial, public, and domestic consumption. (4)

Harold Gold, 1037 North Primrose, Rialto, Calif. 92376 714-875-8117

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Power Electronics, IEEE Trans.
Fundamental technologies used in the control and conversion of electric power. Topics include dc-to-dc converter design, direct off-line switching power supplies, inverters, controlled rectifiers, control techniques, modeling, analysis and simulation techniques, the application of power circuit components (power semiconductors, magnetics, capacitors), and thermal performance of electronic power systems. (4)

Richard Hoft, Electrical and Computer Engineering Dept., University of Missouri, 223 Electrical Engineering, Columbia, Mo. 65211 314-882-3491

Power Engineering Review
Electric power system engineering; includes one-page summaries of all papers accepted for publication in **Energy Conversion**, **Power Delivery**, and **Power Systems**. Also includes the Power Engineering Society Newsletter, selected prize papers, high-interest papers, and other articles of technical interest. (12)

C.J. Essel, 5969 W. 76th St., Los Angeles, Calif. 90045 213-645-3380

Power Systems, IEEE Trans.
Requirements, planning, analysis, reliability, operation, and economics of electrical generating, transmission, and distribution systems for industrial, commercial, public, and domestic consumption.(4)

Harold Gold, 1037 North Primrose, Rialto, Calif. 92376 714-875-8117

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Professional Communication, IEEE Trans.
The study, development, improvement, and promotion of techniques for preparing, organizing for use, processing, editing, collecting, conserving, and disseminating any form of information in the electrical and electronics fields. (4)

Dr. Scott Sanders, Dept. of English Language and Literature, University of New Mexico, Albuquerque, N.M. 87131 505-345-5705

Quantum Electronics, IEEE J.
Quantum electronics and applications, including optoelectronic theory and techniques, lasers, and fiber optics; related systems and subsystems; nonlinear optics; and integrated optics. (12)

Steven R.J. Brueck, Center for High Technology Materials, University of New Mexico, EECE Bldg., Rm. 125, Albuquerque, N.M. 87131 505-277-6033

Reliability, IEEE Trans.
Principles and practices of reliability, maintainability, and product liability pertaining to electrical and electronic equipment. (5)

Dr. Michael Pecht, Mechanical Engineering Dept., University of Maryland, College Park, Md. 20742 301-454-8866

Robotics and Automation, IEEE Trans.
Theory and applications in robot dynamics and control; simulation of robots and manufacturing systems; robot languages; robotic vision and other sensory interfaces; manipulator design; robot locomotion; management of multirobot systems; geometric modeling, other computer-aided design techniques; robot manufacturing; motion planning, task planning, and expert systems in robotics and automation; hardware and software implementation of robotic systems. (6)

Russell H. Taylor, Manufacturing Research Dept., IBM T.J. Watson Res. Cntr., Yorktown Heights, N.Y. 10598 914-945-3693

Semiconductor Manufacturing, IEEE Trans.
Process control techniques; process modeling, simulation, measurements, diagnostics; defect characterization and control; yield analysis and modeling; product design for manufacturability, reliability; product transfer from development to manufacturing; factory design, simulation; automation: models, algorithms, equipment interfaces, etc.; equipment design: modeling and simulation; production control and scheduling; operations management: training, incentives, productivity measures; standards: materials, processes; computer integration: computer-controlled equipment and facilities; and the application of AI and expert systems.

Norman F. Foster, Semiconductor Research Corp., Box 12053, Research Triangle Park, N.C. 27709 919-541-9440

Signal Processing, IEEE Trans.
Transmission, recording, reproduction, processing, and measurement of speech and other signals by digital, electronic, electrical, acoustic, mechanical, and optical means; the components and systems to accomplish these and related aims; and the environmental, psychological, and physiological factors of these technologies. (12)

Pierce Wheeler, RD 3, Box 363, Chester, N.J. 07930 201-879-5746

Signal Processing Magazine
Acoustics, including digital audio, underwater signal processing, and electroacoustics; speech, including speech transmission and coding; enhancement and noise reduction; analysis and reconstruction; synthesis; recognition; production/synthesis; performance evaluation; signal processing, one-dimensional and multidimensional digital signal processing, including discrete Fourier and other transforms; nonlinear analysis; spectral analysis; signal and system identification; filter design and applications; applications to echo cancellation, aids for the handicapped, and radar; image processing; sensor array processing; multidimensional processing; VLSI; and hardware implementations. (4)

Jack Deller, EE Dept., 258 Engineering Building, Michigan State University, East Lansing, Mich. 48824-1226 517-353-8840

Software Engineering, IEEE Trans.
Specification, development, management, test, maintenance, and documentation of computer software. (12)

(Continued on p. 107)

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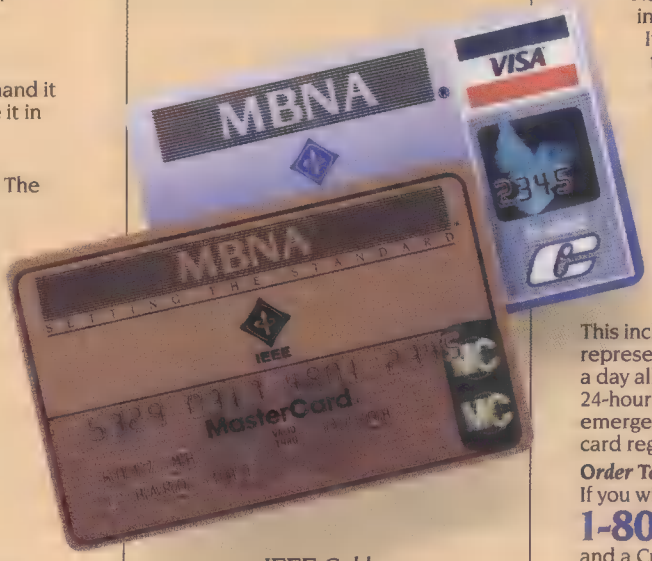
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Computer tools: handle with care

Computer-aided engineering tools can improve productivity, cut costs, and save time. But they can also have some highly detrimental effects, notably dampening innovation.

Systems engineer David K. Murotake and management consultant Thomas J. Allen uncovered these problems in a two-year research project involving 116 engineers and 32 project managers at two electronics companies in the United States. When the engineers used their workstations and software applications for conceptual tasks, their creativity flagged noticeably.



Teresa Labiak

The two men found that the more sophisticated the tools that the engineers had available to them, the more they used them for such tasks as engineering analysis, design, and communications. Moreover, projects on which these tools were used were more likely to be completed on or under budget than were tasks run on less sophisticated tools handling only a single function.

The downside came when the project managers rated the different tasks for innovativeness—defined as the extent to which the problem was solved in a new or creative way. During the conceptual phase of the engineering cycle, increased use of computer tools correlated significantly with less innovativeness in solving problems; at the development end of the cycle, with more innovative problem-solving.

Murotake and Allen observe that computer tools encourage the "cloning" of old solutions. This, in turn, can stifle development of the innovative solutions required during a project's less structured, conceptual phase.

In the more highly structured development phase, however, computer tools match the engineering work very well, the researchers report. They increase efficiency, thereby freeing up time for more creative work.

Murotake and Allen recommend providing engineers with a versatile "kit" of computer tools and encouraging them to use these tools in whatever way best balances productivity and innovativeness. For example, some of the newer visualization tools permit engineers to be more free-wheeling in a project's early phase than did the tools available in 1987 and 1988, when this research was done, Murotake told *IEEE Spectrum*.

Murotake is a senior systems engineer at GE Aerospace, Nashua, N. H. Allen directs the International Center for Research on the Management of Technology at the Massachusetts Institute of Technology, Cambridge. They reported their findings in October at the IEEE International Engineering Management Conference, held in Santa Clara, Calif.

Murotake and Allen's paper, "Computer-Aided Engineering and Project Performance: Managing a Double-Edged Sword," is published in the *Proceedings of the IEEE International Engineering Management Conference*, available from IEEE Service Center, 445 Hoes Lane, Piscataway, N.J. 08855.

Selecting project leaders

Who ought to lead your next project? Research by Edward F. McDonough III demonstrates that different types of projects require different types of leaders. For example, creativity is vital in ground-breaking projects, but experience is key in projects involving minor extensions of technology.

McDonough is an associate professor of business at Northeastern University, Boston, Mass. To clarify the relationships between project performance and problem-solving style, he studied the leaders of 41 new-product development projects in 13 British firms in electronics, automotive products, and other technological industries. (See "An Investigation of the Relationship Between Project Performance and Characteristics of Project Leaders," *Journal of Engineering and Technology Management*, Vol. 6, 1990, pp. 237–260.)

Enjoyment of linking apparently unrelated ideas, searching for novel approaches, and pursuing problems in unknown areas were typical of leaders of higher-performing projects in which new technology had to be developed, McDonough found.

However, an "associative" style of working was not as successful. Associative leaders, he explains, tend to be more systematic, to follow rules and prescribed procedures, and to refrain from looking far beyond existing solutions when attempting to solve problems.

Experience is key in projects requiring the application of existing technology, but less experience was associated with higher performance. Maybe boredom afflicts older, more experienced leaders assigned to projects they consider less challenging, he suggested.

Projects requiring minor extensions of the state-of-the-art technology were handled best by the more experienced leaders. Such projects require more creativity than the applications projects, but less than those involving new technology, McDonough explains.

McDonough plans a comparable study among U.S. firms. Meanwhile, he advises that for new technology projects, the best choice is a leader with a master's degree or Ph.D. who has an innovative problem-solving style. Applications projects are best used as a training ground for new project leaders. As these younger leaders gain experience, they may be moved into those projects that focus on minor modifications, he said.

How to get projects approved

A project is more likely to be approved if the following questions are considered, advises Gerard H. Gaynor, a retired 3M executive from Minneapolis, Minn., who consults on technology management.

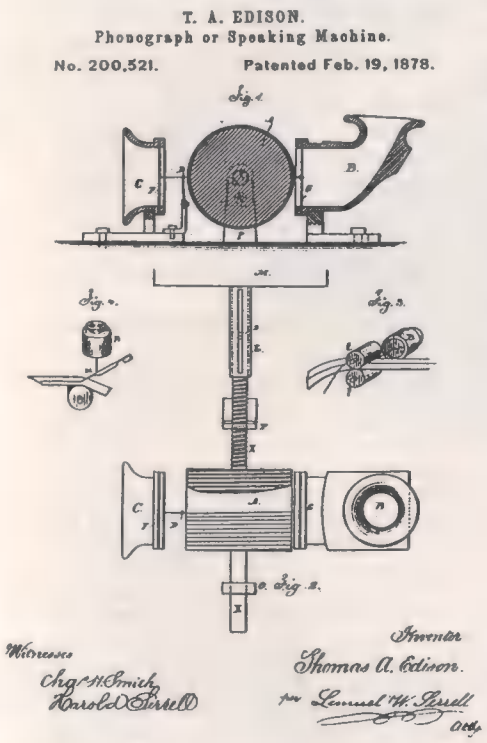
- Are the objectives defined and stated clearly? Does everyone understand their implications?
- Do the objectives support the organization's business, engineering and manufacturing strategies? If these strategies change, will the objectives still support them?
- Why is this project important? What unique results can be expected? Is it a me-too, catch-up-to-the competition project? What could be salvaged if it failed?
- Is it a business or a technology project? What does it mean to the organization's future?
- Is the technology that will be used understood? What is the "value added" in terms of new knowledge?
- Could the projected effort be reduced by joining forces with another organization?
- What other technologies might the competition develop to achieve the same results?
- What will the total cost be to the organization? What capital requirements can be anticipated if the project is successful?
- Are the sales, marketing, and distribution systems in place? If not, what are the alternatives? How would this product or service be introduced? What are the potential product liabilities, environmental problems, etc.?
- Is the necessary staff in place or will new people have to be hired? Is outside talent readily available?
- Have the requirements for the project manager been identified? Does the person exist? Can he or she be hired?

Gaynor presented his list in "Selecting Projects," *Research-Technology Management*, July–August 1990, pp. 43–45.

Coordinator: Michael F. Wolff
Consultants: Robert F. Cotellessa, Clarkson University; John Griffin, McKinsey & Co.

Guide book for phonograph collectors

Between 1877, when Thomas A. Edison invented the phonograph, and 1912, when the external-horn machines lost their popularity, the U.S. Patent Office granted over 2000 patents for inventions and over 70 for designs to more than 1000 inventors in the sound-recording field. Edison, the



most prolific of the inventors, eventually was awarded 134 patents.

It took an avid collector of early phonographs, Allen Koenigsberg of Ditmas Park, N.Y., to track those 1000-plus patents down and read and study them all. The result is a book featuring descriptions of, and Koenigsberg's comments on, 101 of the most significant, together with some of the original patent-office drawings. The material could, however, have benefited from an editor's clarification of some of the points the phonophile author tries to make.

Return to those days of yesteryear, then, and study the drawing of T.A. Edison's *Phonograph or Speaking Machine* in Patent No. 200 521 of Feb. 19, 1878. Then move on to patents for things like a solid-wax phonogram cylinder; a combined cash-register and phonograph; coin-operated phonographs, including a coin-controlled graphophone; graphophones; talking machines; and the springs, motors, horns, and other mechanical devices needed to make the contraptions work.

For the record (no pun intended), Koenigsberg also includes a chronological list of all the U.S. sound-recording patents that he could locate for that inventive period ending in 1912. The 159-page *The Patent History of the Phonograph, 1877–1912,* published in a 9-by-12-inch (23-by-30-centimeter) paperback spiral binding, sells for US $54.95. *Contact: APM Press, 502 E. 17th St., Brooklyn, N.Y. 11226.*

SOFTWARE

The virtuoso workstation

The kitchen sink and then some seems to be what Bimillennium Corp. has integrated in its new HiQ "power-computing" software. Slated for release in April, HiQ integrates mathematics capabilities and engineering functions in an engineering analysis environment whose breadth has never before been seen in a single software package. The initial version is targeted at the Apple Macintosh. One for Unix workstations, which implements a graphical user interface closely akin to the Apple version, is due in July.

In particular, a trio of capabilities is "key to the software's uniqueness," pointed out Bimillennium's executive vice president of sales and marketing, Larry McGraw. These comprise integrated graphics, a high-level script language, and an intuitive interface for creating an engineering notebook for any application.

In addition, an extensive library of some 500 engineering and mathematics functions covers dozens of application areas. Included are all the standard engineering functions, such as statistical functions, and the special and matrix functions typically available in large commercial or public domain libraries. Lower-level functions cover such mundane but important tasks as determining the maximum value of a list of arguments or finding the integer part of a rational number.

Hundreds of other, intermediate-level functions in the library include essentially all the significant routines in numerical linear algebra and applied mathematics, together with a rich complement of digital signal-processing, probabilistic, and data analysis functions.

And there are also more than 100 sophisticated Problem Solver algorithms for handling linear and nonlinear problems, including integrating functions, solving differential equations with initial- and boundary-value conditions, determining the roots of real or complex functions, and optimization. According to McGraw, "The core math package is as powerful, or more so, than commercial math packages like Matlab, Mathematica, Mathcad and TK Solver."

Putting all the functions together took more than 20 man-years of effort, according to the company. "We evaluated all of the best algorithms we could find, wrote many of our own, and then modified them to work faster," said David M. Russell, Bimillennium's executive vice president and chief technical officer.

HiQ is said to provide the speed and numerical performance of a mainframe computer on a desktop Macintosh with a 68881/68882 math coprocessor. At any rate, a 100-by-100 matrix can be converted with 80-bit precision in less than 10 seconds, while a linear system of 100 equations can be solved in 5 seconds on the new Macintosh IIfx.

As for the graphics capability, it can be used for a functional or data representation in two or three dimensions of typical data employing vectors, matrices, or lattices. Graphical features and attributes may be manipulated interactively completely within the graphics environment.

Programs can be written with the high-level QScript object-based language. With it, the user can create any permanent function needed to solve a problem using HiQ's basic functions and the Problem Solvers. There is no need to write long, complicated Fortran programs to create building blocks for an application.

The third unusual feature, the engineering project notebook, keeps track of every step of a problem-solving process. Like a standard engineering notebook, it holds experimental or model-generated data, algorithms, program code, notes, and results.

In addition to containing data (scalars, vectors, and matrices), two- and three-dimensional graphs, QScript programs, annotations, and Problem Solver documents, the notebook's objects can be used to invoke custom editors that have been designed for the engineer's special use. Further, objects within the notebook can be moved around, on, or between the pages of the notebook, and they can be deleted, added, or shared between notebooks or users across a network.

Introductory price of HiQ is US $495 for 90 days after its availability; after that the price goes to $695. *Contact Larry McGraw, Bimillennium Corp., 101 Albright Way, Los Gatos, Calif. 95030; 408-866-2010; fax, 408-866-2305; or* **circle 61.**

Public domain software listed

A free catalog to over 500 shareware disks is available from the New England Software Library. The *1991 Reference Guide to Public Domain and User Supported Software* includes disks for electrical, mechanical, and civil engineering, mathematics, and statistics, as well as utilities for programmers and engineers.

The more popular disks contain programs for computer-aided design, expert systems, electrical filter design, Fourier transforms, equation processors, and graph plotting. There is a distribution charge of $3–$5 per disk. *Contact: New England Software Library, RR1, Box 260, Starksboro, Vt. 05487; 802-453-3556.*

Robot simulation for PCs

A British company has developed what it says may be the first robot-simulation program for a personal computer. Workspace from Robot Simulations runs on any IBM PC or compatible having EGA or VGA graphics and a hard-disk drive. Targeted at

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engineers who use robots, design robot workcells, or compare the efficiency of different robots in performing tasks, the program simulates and displays robot workcells in real time. It includes a full kinematic modeler, three-dimensional graphics, and facilities for off-line programming.

The program automatically calculates cycle times and checks for collisions between moving objects. Several robots can be simulated in one workcell, which can be replayed for a realistic visualization of complex workcells.

Workspace will also model tooling, automatic feeds and conveyors, automatic programmable vehicles, linear tracks, and turntables.

Computer-aided design capability includes true 3-D wireframe with hidden-line removal, blocks and cylinders, extruded objects, curved-line and surface approximation, and object-attachment hierarchy. Pull-down menus and an extensive help facility make the program easy to use. *Contact: J. Owens, Robot Simulations, High Bridge House, High Bridge, Newcastle on Tyne, England NE1 1EW; (44+91) 221 1087; fax, (44+91) 230 0281, or* **circle 60**.

HISTORY

'Pearl Harbor radar' on display

War buffs and others may enjoy visiting an unusual museum devoted to the preservation of noteworthy electronics technology. One of the newest and most prized acquisitions of the Historical Electronics Museum is a pair of radars of the type that detected the Japanese planes flying to attack Pearl Harbor on Dec. 7, 1941.

Designated the SCR-270, this long-range 110-megahertz radar was manufactured by Westinghouse Electric Co., Baltimore, Md. In the predawn hours of Sunday, Dec. 7, the then-secret device (SCR was supposed to stand for Signal Corps Radio) was being operated by a junior radar operator at a place called Opana Point on Oahu, where much of the U.S. fleet was anchored. The incoming planes were picked up at 7:02 a.m., when they were more than 100 miles (160 kilometers) out. They registered so strong a signal that the A-scope presentation was driven off-screen.

The operator knew he was onto something, but he had no one to alert. The plotting room had just shut down. And when reached by phone, the Army Air Corps lieutenant in charge of the installation, who had arrived at his command only the previous week, declined to pass on the information to a higher authority. The radar operator continued tracking the targets to within 30 mi (48 km) of Oahu. They were lost at 7:39 a.m. because of the shadowing effects of the mountains.

The museum is busily refurbishing the first of the radars, which rely on a horizontally polarized dipole array. One radar will remain in the museum; the other may be shipped to Hawaii.

Other exhibits at the museum, which emphasizes radar, countermeasures, and communications, present 50 years of radar from 1935–85, and trace a partial history of the electron tube, starting with the 1908 Lee De Forest Audion and moving through the developments of the 1960s. The assortment of ground and airborne radar sets includes the antenna and klystron of the modern airborne warning and command system (AWACS) surveillance systems; the first automatic anti-aircraft gun-control tracking radar, the SCR-584, which was a key element in Britain's successful defense against the V-1 buzz bombs; and the APQ-35, the first complete airborne fire control system. The museum's collection also includes many receivers and transmitters, some still in operation, as well as a research library.

As a nonprofit, IRS-qualified corporation, the museum welcomes equipment and library donations from individuals and corporations. All contributions are tax deductible. The museum is located in Linthicum, Md., near the Baltimore-Washington International Airport, and is open weekdays from 9 a.m. to 3 p.m. Admission is free. *Contact: Historical Museum Inc., Box 1693, M/S 4610, Baltimore, Md. 21203; 301-765-2345.*

Birth of Babbage's Engine

Mark your calendars for a July 1 opening at London's National Museum of Science and Industry—it's the start of an exhibition of the work of mathematician Charles Babbage. The centerpiece of the display will be the first full-size Babbage engine ever built by anyone, let alone the inventor.

Few realize that Babbage, a towering figure in the history of computing, never completed any of his mechanical calculating engines. He probably failed because of limitations of 19th century machine-tool technology, according to Doron Swade, the Science Museum's curator of computing. "By building a Babbage engine to original designs, we have set out to prove that these machines could have worked in Babbage's day," said Swade.

Construction of Babbage's full-size Difference Engine No. 2 from designs dating from 1847 began last October right out in public view at the museum. The engine has 4000 parts, weighs 3 tons and measures 10 feet long, 6 ft high, and 1.5 ft wide (3 by 1.8 by 0.45 meters). Not coincidentally, the exhibit will open for the 200th anniversary of Babbage's birth. He died in 1871.

In addition to the full-size engine, the exhibition will feature the Science Museum's collection of Babbage pieces and unique archival material. Total cost of building the engine and mounting the exhibit, which is to last six months, is £500 000 (US $1 million). A large part of this has already been raised from a group of computer, electronics, and communications companies.

Those attending the exhibit who might care to mix business with pleasure may consider registering for the International Conference on Computing scheduled for July 1–3 at the Imperial College in London. The conference is being organized under the auspices of Britain's Institution of Electrical Engineers.

Coordinator: Alfred Rosenblatt

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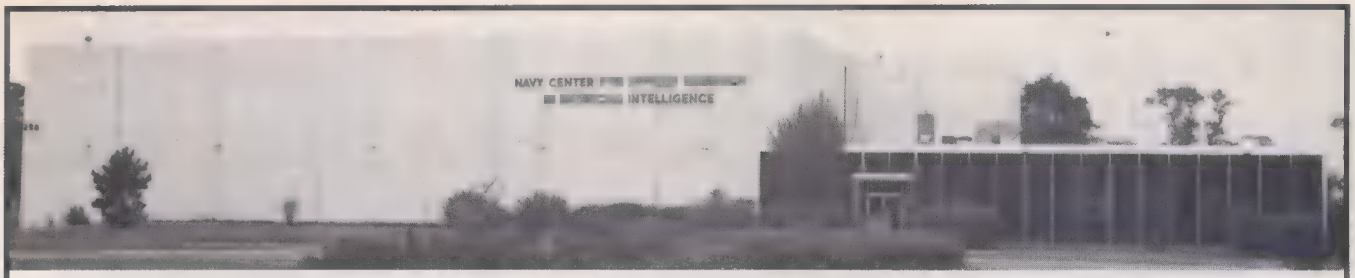
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ERIM

At The Forefront Of Sensor Technology

(Continued from p. 15)

i860 Microprocessor Architecture. Eds. *Margulis, Neal, Fisher, Elizabeth, and Paris, Janis,* Osborne/McGraw-Hill, New York, 1990, 631 pp., $29.95.

Inside Supercard (The Complete Guide for Macintosh Developers and Advanced Users). *Himes, Andrew, and Ragland, Craig,* Microsoft Press, Redmond, Wash., 1990, 623 pp., $22.95.

The Programmer's Apple Mac Sourcebook. Ed. *Hogan, Thom, et al.,* Microsoft Press, Redmond, Wash., 462 pp., $22.95.

Introduction to Applied Solid State Physics- 2nd Edition. *Dalven, Richard,* Plenum Press, New York, 410 pp., $39.50.

Neural and Automata Networks (Dynamical Behavior and Applications). *Goles, Eric, and Martinez, Servet,* Kluwer Academic Publishers, Dordrecht, The Netherlands, 1990, 250 pp., $69.

Control of Computer-Based Technology for People with Disabilities: An Assessment Manual. *Lee, Kathy S., and Thomas, Debra Jay,* University of Toronto Press, Toronto, 1990, 310 pp., $50.

Artificial Intelligence: An Engineering Approach. *Schalkoff, Robert J.,* McGraw-Hill, New York, 1990, 646 pp., $46.95.

Automating Electric Utility Distribution Systems. Eds. *Gnadt, P.A., and Lawler, J.S.,* Prentice Hall, Englewood Cliffs, N.J., 1990, 25 pp., $51.40.

Interconnection Networks for Large-Scale Parallel Processing-2nd Edition. *H. Jay,* McGraw-Hill, New York, 390 pp., $39.95.

Superconducting Devices. Eds. *Riggiero, Steven T., and Rudman, David A.,* Academic Press, Boston, 1990, 396 pp., $49.95.

Advanced Research in VLSI (Proceedings of the Sixth MIT Conference). Ed. *Dally, William J.,* MIT Press, Cambridge, Mass. 1990, 400 pp., $50.

Measurement of High-Speed Signals in Solid State Devices (Volume 28: Semiconductors and Semimetals). Eds. *Marcus, Robert B., et al.,* Academic Press, Boston, 1990, 438 pp., $85.

UK IT 1990 Conference. *Multi-authored,* Institution of Electrical Engineers, London, 1990, 441 pp., $108.

Computer Vision for Electronics Manufacturing. *Pau, L.F.,* Plenum Press, New York, 1990, 324 pp., $65.

Future Trends in Distribution Switchgear. *Multi-authored,* Institution of Electrical Engineers, London, 1990, 129 pp., $58.

Concise International Encyclopedia of Robotics—Applications and Automation. Ed. *Dorf, Richard C.,* Wiley Interscience,

(Continued on p. 90F)

ENGINEERING
on the GRAND SCALE
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The Lawrence Livermore National Laboratory is an applied science R&D facility operated by the University of California for the U.S. Department of Energy and is located in the San Francisco Bay Area. We have approximately 8,000 employees and are engaged in basic and applied research and development. We anticipate adding to our highly qualified staff individuals in the following areas:

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To model the propagation, coupling and scattering of electromagnetic radiation in the presence of geometrically complex objects in both linear and nonlinear regimens. The modeling of semiconductor device behavior in harsh and adverse environments is a significant problem of current interest. Analytical techniques using both finite element and finite difference will be used. Good theoretical, analytical and computational skills are required for these challenging problems.

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To design and implement a range of closed loop control systems from extremely high precision applications to very complex process flow systems.

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To design, develop, and test a wide variety of high voltage and/or pulse power devices and systems. Work involves high power control and regulation, and high voltage/high speed switching, grounding, and shielding.

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To conduct research in experimental photonics which includes: design, fabrication, and testing of diode lasers, ultrahigh speed and/or nonlinear optoelectronics.

Electro-Optics Engineers
To develop advanced ultra-fast optoelectronic and integrated optic components for processing very fast optical and electrical signals. Requires a broad background in both experimental solid state physics and quantum electronics with emphasis on integrated optics, diode lasers, or optoelectronic modulators.

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To design and implement mini and microcomputer based systems. Typical applications include the development of complex real time control systems, machine tool control, database management systems, and networking applications. Positions involve familiarity with DEC VAX family of computers, high-level and Assembly languages, digital logic system design and control system design.

Resumes may be sent in strict confidence to: **Howard Revel, LAWRENCE LIVERMORE NATIONAL LABORATORY, P.O. Box 5510, Dept. A91009, Livermore, California 94550.**

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RECENT BOOKS

(Continued from p. 90D)
Somerset, N.J., 1990, 1190 pp., $99.95.

At the Heart of the Bomb—The Dangerous Allure of Weapons Work. *Rosenthal, Debra,* Addison Wesley, New York, 1990, 244 pp., $18.95.

Languages and Compilers for Parallel Computing. Eds. *Gelernter, David, et al.,* MIT Press, Cambridge, Mass., 1990, 553 pp., $40.

Waves and Fields in Inhomogeneous Media. *Chew, Weng Cho,* Van Nostrand Reinhold, New York, 1990, 611 pp., $56.95.

Learn Microsoft Excel Now-Special Edition. *Soucie, Ralph,* Microsoft Press, Redmond, Wash., 1990, 328 pp., $29.95.

Windows 3 Companion. *Lorenz, Lori L., and O'Mara, R. Michael,* Microsoft Press, Redmond, Wash., 1990, 519 pp., $27.95.

Analogue IC design: the current-mode approach. Eds. *Toumazou, C., et al.,* Peter Peregrinus, London, 1990, 646 pp., $85.

Toolbook Companion. *Pierce, Joseph R.,* Microsoft Press, Redmond, Wash., 1990, 693 pp., $27.95.

Eighth International Conference on Video Audio & Data Recording. *Multi-authored,* Institution of Electrical Engineers, London, 1990, 182 pp., $70.

Electronics Packaging Forum (Volume 1). Ed. *Morris, James E.,* Van Nostrand Reinhold, New York, 1990, 347 pp., $56.95

Learn Microsoft Word Now-Special Edition. *Rampa, Janet,* Microsoft Press, Redmond, Wash., 1990, 400 pp., $29.95.

Third International Conference on Road Traffic Control. *Multi-authored,* Institution of Electrical Engineers, London, 1990, 218 pp., $78.

Learn Microsoft Word for Windows Now-Special Edition. *Boom, Michael,* Microsoft Press, Redmond, Wash., 1990, 414 pp., $29.95.

Artificial Intelligence: An Engineering Approach. *Schalkoff, Robert J.,* McGraw-Hill, New York, 1990, 646 pp., $46.95.

Microsoft Quickpascal Programming. *Jamsa, Kris,* Microsoft Press, Redmond, Wash., 1990, 688 pp., $22.95.

The Amateur Astronomer. *Moore, Patrick,* W. W. Norton & Co., New York, 1990, 337 pp., $35.

Telecommunications and the Computer-3rd Edition. *Martin, James,* Prentice-Hall, Englewood Cliffs, N. J., 1990, 720 pp., $36.75.

Measurement of High-Speed Signals in Solid State Devices. Ed. *Marcus, Robert B.,* Academic Press, Boston, 1990, 438 pp., $85.

Microsoft QuickC Programmer's Toolbox. *Craig, John Clark,* Microsoft Press, Redmond, Wash., 1990, 525 pp., $22.95.

Machine Vision for Three-Dimensional Scenes. Ed. *Freeman, Herbert,* Academic Press, San Diego, Calif., 1990, 419 pp., $59.95.

The Waite Group's Microsoft QuickC Programming. *Waite, Mitchell, et al.,* Microsoft Press, Redmond, Wash., 1990, 637 pp., $22.95.

Alex Randall's Used Computer Handbook. *Randall 5th, Alexander, and Bennett, Stephen J.,* Microsoft Press, Redmond, Wash., 1990, 215 pp., $14.95.

Curves and Surfaces for Computer Aided Geometric Design. A Practical Guide-2nd Edition. *Farin, Gerald,* Academic Press, Boston, 1990, 444 pp., $39.95.

Advancing Production Management with Standard Cost and Operational Analysis. *Broten, Lorne H. S., et al.,* APM Systems, Saskatoon, Sask., Canada, 1990, 280 pp., $249.

Smalltalk-80 Programmation par objets. *Dugerdil, Philippe,* Presses Polytechniques Romandes, Lausanne, Switzerland, 1989, 297 pp., 68 Swiss Francs.

(Continued on p. 90 I)

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Programmer's Guide to Fortran 90. *Brainerd, Walter S., et al.,* McGraw-Hill, New York, 1990, 410 pp., $34.95.

Semiconductor Material and Device Characterization. *Schroder, Dieter K.,* John Wiley & Sons, New York, 1990, 599 pp., $59.95.

Mastering Technical Writing. *Mancuso, Joseph C.,* Addison-Wesley, Reading, Mass., 1990, 272 pp., $27.95.

UNIX System V Release 4–An Introduction. Ed. *Rosen, Kenneth H.,* Osborne/McGraw-Hill, Berkeley, Calif., 1990, 1200 pp., $29.95.

Essentials of Error-Control Coding Techniques. Ed. *Imai, Hideki,* Academic Press, San Diego, Calif., 1990, 337 pp., $55.

Using Turbo C++. *Schildt, Herb,* Osborne/McGraw-Hill, Berkeley, Calif., 1990, 755 pp., $24.95.

Dye Laser Principles with Applications. Eds. *Duarte, F. J., et al.,* Academic Press, San Diego, Calif., 1990, 457 pp., $64.50.

ISDN: Concepts, Facilities, and Services. *Kessler, Gary C.,* McGraw-Hill, New York, 302 pp., $44.95.

Using ANSI C in UNIX. *Feibel, Werner,* Osbourne/McGraw-Hill, Berkeley, Calif., 1990, 626 pp., $24.95.

Electrical Impedance Tomography. Ed. *Webster, J.G.,* Adam Hilger, Bristol, England, 1990, 224 pp., $70.

How To Solve Problems: For Success in Freshman Physics, Engineering, and Beyond–2nd Edition. *Scarl, Donald,* Dosoris Press, Glen Cove, N.Y., 1990, 100 pp., $8.95.

SAS System: A Programmer's Guide. *Aronson, Monte, and Aronson, Alvera L.,* McGraw-Hill, New York, 1990, 321 pp., $39.95.

IBM Microcomputers: A Programmer's Handbook. *Sanchez, Julio, and Canton, Maria P.,* McGraw-Hill, New York, 1990, 503 pp., $44.95.

Implementing Discrete Mathematics: Combinatorics and Graph Theory with Mathematica. *Skiena, Steven,* Addison-Wesley, Redwood City, Calif., 1990, 352 pp., $43.25.

Design To Test–2nd Edition: A Definitive Guide for Electronic Design, Manufacture and Service. *Turino, Jon,* Van Nostrand Reinhold, New York, 1990, 368 pp., $49.95.

Distributed Computer Control for Industrial Automation. *Popovic, Dobrivoje, and Bhatkar, Vijay P.,* Marcel Dekker, New York, 1990, 712 pp., $125.00.

Signals: The Science of Telecommunications. *Pierce, John, and Noll, Michael A.,* W.H. Freeman, New York, 1990, 256 pp., $32.95.

ESD From A to Z: Electrostatic Discharge Control for Electronics. *Kolyer, John M., and Watson, Donald E.,* Van Nostrand Reinhold, New York, 1990, 250 pp., $39.95.

Signals: The Science of Telecommunications. *Pierce, John, and Noll, Michael A.,* W.H. Freeman and Co., New York, 1990, 256 pp., $32.95.

Electronic Materials. Ed. *Braithwaite, Nicholas, et al.,* Butterworths, Stoneham, Mass., 1990, 336 pp., $34.95.

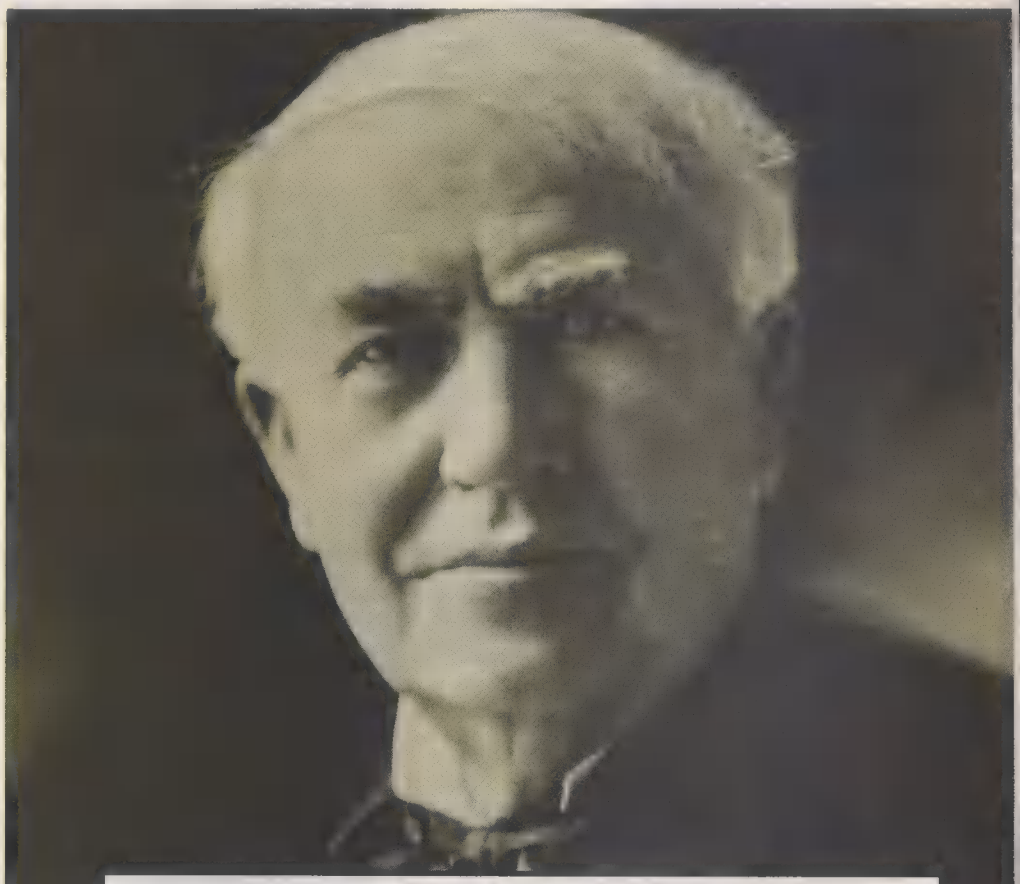
Minimalist Mobile Robotics. *Connell, Jonathan H.,* Academic Press, San Diego, Calif., 1990, 175 pp., $29.95.

Mars Beckons. *Wilford, John Noble,* Alfred A. Knopf, New York, 1990, 244 pp., $24.95.

Robot Technology and Applications. Ed. *Rembold, Ulrich,* Marcel Dekker, New York, 1990, 696 pp., $150.

Digital Signal Processing Applications Using the ADSP-2100 Family. Ed. *Mar, Amy,* Prentice Hall, Englewood Cliffs, N.J., 1990, 628 pp., $38.

Mastering Electronics–3rd Edition. *Watson, John,* McGraw-Hill, New York, 1990, 427 pp., $19.95.



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Electrical/Computer Engineering

A tenure track position is anticipated in the Department of Engineering at Swarthmore College starting in September 1991. Beginning Assistant Professor preferred but an appointment at a higher rank, consistent with experience and qualifications, will also be considered. Applicants must have a primary interest in undergraduate teaching and the ability to develop a relevant research program. A Ph.D. in electrical engineering with a background in computer engineering is expected. We expect the candidate would also assist in supporting our computer science program. Swarthmore College, located in suburban Philadelphia, is a small coeducational institution devoted to undergraduate teaching and research. Applicants should submit a complete resume and the names of at least three references to:

Professor Nelson A. Macken
Chairman
Department of Engineering
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90M

ELECTRO-OPTICAL SYSTEMS ENGINEERS

Battelle, a world leader in contract research and professional services, has an immediate need for experienced engineers with advanced degrees in electrical engineering or a related discipline. This is an opportunity to work closely with a talented group of research engineers on electro-optical systems projects. The positions are further described as follows:

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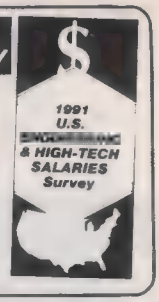
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The program is open to U.S. citizens who are full-time faculty or graduate students at accredited U.S. academic institutions. For information or applications, contact: **Research & Development Laboratories, Summer Research Program Office, 5800 Uplander Way, Culver City, CA 90230-6608,** or call **(800) 677-1363** or **(213) 410-1244.** Applications must be received by February 1, 1991 (faculty) or April 1, 1991 (graduate students).

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Further particulars and application forms may be obtained from Appointments (38757), Association of Commonwealth Universities, 36 Gordon Square, London WC1H OPF, U.K.; or from the Appointments Unit, Registry, University of Hong Kong, Hong Kong. (Fax (852)-5592058; E-mail APPTUNIT@HKUVM.HKU.HK).

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IEEE encourages employers to offer salaries that are competitive, but occasionally a salary may be offered that is significantly below currently acceptable levels. In such cases the reader may wish to inquire of the employer whether extenuating circumstances apply.

Academic
Positions Open

University of Illinois at Urbana-Champaign. The Departments of Electrical and Computer Engineering invites applications for several tenure track and tenured faculty positions. Applicants must have an earned Ph.D., outstanding academic credentials, and an ability to teach effectively at both the graduate and undergraduate levels. Selected candidates will be expected to initiate and carry out independent research and to perform academic duties associates with our B.S., M.S., and PhD. programs. The department has one of the largest programs in the United States granting approximately 400 B.S., 100 M.S. degrees and 65 Ph.D. degrees. Research is conducted in acoustics, bioengineering, communications, computer engineering, computer vision & robotics, control, electromagnetics, integrated circuits, laser and electro-optics, microelectronics, power systems and power electronics, signal processing, and remote sensing. Particular need exists for faculty in communication systems. However, all candidates judged to have outstanding qualifications for a position in any of the above areas will be interviewed. The University of Illinois is an equal opportunity/affirmative action employer. Send resume, with references and a list of publications, to: Faculty Search Committee, Department of Electrical and Computer Engineering, 1406 West Green Street, University of Illinois, Urbana, IL 61801.

Research Associate, Microwave CAD. The NSF I/UCR Center for Microwave/ Millimeter-Wave CAD at the University of Colorado, Boulder has a post-doctoral opening for research in the area of computer-aided design of microstrip antennas. The position requires a Ph.D. in Electrical Engineering or a related field. The candidate must have a strong background in CAD techniques suitable for microstrip antennas and arrays with a dielectric layer covering, preferably having worked on a Ph.D. thesis in this field. Also, complimentary expertise in CAD of microstrip circuits is desired. The candidate should be capable of handling research contracts and should be able to supervise graduate students on research projects. Teaching responsibilities may also be assigned as needed. The initial appointment is for a minimum period of one year with the possibility of renewal. The salary will be in the range of $37.5K to$40K, depending upon relevant experience. To apply, send a resume (with names of references) to: Director, MIMICAD Center, University of Colorado at Boulder, Campus Box 425, Boulder, CO 80309-0425. Deadline for applications is February 15, 1991. The university of Colorado at Boulder has a strong institutional commitment to the principle of diversity in all areas. In that spirit, we are particularly interested in receiving applications from a broad spectrum of people including women, members of ethnic minorities and disabled individuals.

University of Illinois at Chicago—Instructorships and Tenure-Track faculty positions in electrical engineering and computer science at both the junior and senior level are available. Rank and salary commensurate with qualifications. An earned Doctorate in EE or CS must be completed by date of appointment, but not for the instructorships. Demonstrated teaching and research abilities are highly desirable. For full consideration, please send resume, list of publications, and the names of at least three references by April 30, 1991, to Dr. Wai-Kai Chen, Head, Department of Electrical Engineering and Computer Science (M/C 154), University of Illinois at Chicago, P.O. Box 4348, Chicago, IL 60680. The University of Illinois is an Affirmative Action/Equal Opportunity Employer.

The Mechanical Engineering Department at Carnegie Mellon University invites applications for a tenure-track position at the Assistant Professor level Commencing September 1991 in the area of Robotics and Controls. This position is joint with the Robotics Institute at Carnegie Mellon. Applicants must have a Ph.D. in Mechanical Engineering (or closely related field). Duties include teaching undergraduate and graduate courses, and research. Appointments at a higher rank will be considered for qualified applicants having a proven record of grant support. Submit application, complete resume, and names of three references to Professor G.B. Sinclair, Mechanical Engineering Department, Carnegie Mellon University, Schenley Park, Pittsburgh, PA 15213-3890. Closing date for applications is February 15, 1991. Carnegie Mellon University is an affirmative action/equal opportunity employer.

Clemson University. Department of Electrical and Computer Engineering. The Department of Electrical and Computer Engineering at Clemson University invites applications for tenure/ tenure-track positions, primarily at the assistant professor level. A Ph.D. is required. Candidates with research interests in one of the following areas are sought: communications and digital signal processing; networks and distributed computing; quantitative analysis of computer architectures; electromagnetic analysis of active devices (microwave, millimeter wave, or electro-optic); and multidisciplinary applications in power systems (e.g. power and artificial intelligence; power and computer communications). A successful candidate must exhibit exceptional potential for research and teaching. Clemson University's College of Engineering was listed as one of the United States' "up-and-coming" engineering graduate programs in the March 19, 1990, issue of U.S. News and World Report. The ECE Department comprises thirty-six full-time faculty, approximately 700 undergraduate students, and 140 graduate students. It offers B.S., M.S., and Ph.D. degrees in both electrical engineering and computer engineering. Facilities and/ or groups bearing on the areas indicated above include the Clemson University Electric Power Research Association (CUEPRA); a microcircuits reliability research group with a class 100 clean room; automated microwave measurement facilities to 26 GHz; an image processing laboratory; a Center for Computer Communication Systems. Resumes, supported with a list of references, should be sent to L. Wilson Pearson, Head; Department of Electrical and Computer Engineering; 102 Riggs Hall; Clemson University; Clemson, SC 29634-0915. Initial screening of applicants will begin January 15, 1991 and continue until positions are filled. Clemson University is an Equal Opportunity/Affirmative Action Employer.

University of Southern California. The Department of Electrical Engineering-Systems at the University of Southern California has faculty positions available at the Assistant, Associate for Full Professor level in the following areas: Communications Science (optical communications with an experimental emphasis, digital signal processing), and Signal and Image Processing (algorithm oriented; and, hardware for signal processing-analog, digital). Computer Engineering within the Electrical Engineering-Systems department is expanding, and looking to fill positions in the following areas: VLSI/CAD, networks (optical type), and architecture with an emphasis on hardware. Additionally, we are looking for a full-time instructor (M.A. only required) to support the Computer Science/Computer Engineering undergraduate degree program. For all openings, please send a resume and the names of at least three academic reference to Jerry M. Mendel, Chairman, Department of Electrical Engineering-Systems, University of Southern California, Los Angeles, CA 90089-0781. USC is an equal opportunity/affirmative action employer.

E.E. Faculty Positions at Auburn University. E.E Department currently has openings for faculty with expertise in any of the following areas: computer engineering, VLSI design, electronic circuit design or power engineering. Applicants must be research oriented, have a Ph.D. and an electrical engineering background. Senior level appointments are available. Foreign national applicants must clearly indicate visa status. Auburn is Alabama's land-grant university with 22,000 students. The E.E. Department has 30 faculty and currently enrolls approximately 750 undergraduate and 120 graduate students. The annual research funding level is approximately $3 million. Interested persons may send resumes to Professor L.L. Grigsby, Chairman of Faculty Search Committee, Department of Electrical Engineering, Auburn University, AL 36849-5201. Minorities and women are encouraged to apply. Auburn University is an equal opportunity and affirmative action employer.

Texas A&M University. The Electrical Engineering Department has several openings for tenure track faculty at all ranks. Applicants must have a Ph.D. degree. For senior positions, the individuals should have a proven record of scholarly contributions, and for junior positions, demonstrated potential for quality research and teaching is necessary. The salary is competitive and commensurate with qualifications and experience. The Department has 1300 undergraduate students, 350 graduate students and a faculty of 56. Currently the active areas of graduate programs include digital and analog microelectornics , electronic and magnetic materials and devices, electromagnetics, micorowave engineering, computer engineering, electrooptics, telecommunications, controls, signal processing, electric power systems, and power electronics. Qualified individuals having expertise in any of these research areas are urged to apply. The Department has a particular interest in hiring outstanding faculty in the areas of computer engineering, microelectronics, electronic materials, electromagnetics, microwave engineering, power systems automation, solid state electronics and signal processing. Applicants should send a complete resume, including names and addresses of three references to Dr. J.W. Howze, Department Head, Electrical Engineering Department, Texas A&M University, College Station, TX 77843. Texas A&M University is an equal

opportunity/affirmative action employer, and actively seeks the candidacy of women and minorities.

Professor of Optics—The Institute of Optics, University of Rochester, invites applications for ■ tenure track position ■■ Assistant Professor or Associate Professor of Optics. A Ph.D. degree in Physics, Optics, or Electrical Engineering is required. Particular research interest is optical engineering. The successful candidate will be expected to teach one course per semester and to pursue ■ vigorous program of research. Laboratory space and start-up research funds will be provided. The Institute of Optics offers programs leading to the B.S., M.S., and Ph.D. degrees in Optics and has approximately 150 graduate students in residence at the present time. Qualified women and minority persons are especially urged to apply. Send a resume and names of three reference to: Professor Duncan T. Moore. Director, The Institute of Optics, University of Rochester, Rochester, New York 14627. An Equal Opportunity Employer.

Postdoctoral Fellowships in Electronic Imaging. The University of Rochester announces the availability of prestigious two-year postdoctoral appointments to EASTMAN-KODAK FELLOWSHIPS IN ELECTRONIC IMAGING starting ■■ or after 1 January 1991. These are challenging positions for superior scholars who wish to pursue basic research topics in Electronic Imaging and Digital Imaging Science including image processing, photodetector arrays, color science, automatic pattern recognition, and active and passive remote sensing. Research is to be conducted in existing laboratories at the University of Rochester in close cooperation with University faculty and senior engineering scientist from the Eastman-Kodak Company. Qualifications required for these positions include ■ Ph.D. degree in Electrical Engineering, Optics, Computer Science, or Physics with some specialization in Imaging Science or Electronic Imaging. An excellent mathematical background and extensive computer experience are required. Demonstrated excellence in research (describe thesis) and potential for significant research contributions are major factors in our evaluation procedure. There is also to be an emphasis on developing relevant research on topics that are suitable for funding from external sources. Please send ■ resume together with a list of three or more professional references and with a brief (4 pages or less) description of your specific research interests. Applications will be considered until the positions have been filled. This is ■ continuing program of research that is associated with the establishment of ■ major Consortium dedicated to Electronic Imaging in the Rochester Community. Annual salary is $30,000 to $35,000 based on a 40-hour week. Send applications to the attention of Professor Nicholas George, Associate Dean for Research, Institute of Optics, College of Engineering & Applied Science, University of Rochester, Rochester, NY, 14627. Equal opportunity employer (M/F).

Vacancy Announcement. University of Idaho—Faculty Positions. Electrical Engineering, University of Idaho invites applications for tenure track positions at the assistant professor level; however, outstanding applicants at higher levels will also be considered. While specialization in digital systems, electronics, power, or electromagnetics is desired, outstanding candidates in all areas are encouraged to apply. Qualifications for each position include an earned PhD in electrical engineering or a closely related field, excellent teaching ability, potential for establishing a strong research program and US citizenship or permanent residency. Successful applicants will teach at the undergraduate and graduate levels and conduct research with graduate students in appropriate specialty areas. The Department offers BS, MS, MEngr, and PhD degrees in electrical engineering and BS, MS, and MEngr degrees in computer engineering. The University of Idaho is the landgrant university in Idaho and has statewide responsibility for engineering education. The main campus is located in Moscow, in the heart of the Palouse region of northern Idaho approximately 10 miles from Washington State University in Pullman, Washington. The University of Idaho has over 9,000 students, and the Department of Electrical Engineering has approximately 320 undergraduate students, 50 full-time graduate students, and 16 faculty. Active areas of research include power, analog electronics, control systems, communications, digital systems, and very large scale integrated (VLSI) circuits. The Microelectronics Research Center (MRC), established within the College of Engineering in 1985, concentrates on the design of VLSI computer chips. The MRC was recently selected as one of nine Space Engineering Research Centers by NASA. Applications will be accepted until the positions are filled; closing date will be no earlier than February 1, 1991. Send letter, resume, and names of three references to Dr. John E. Purviance, Department of Electrical Engineering, University of Idaho, Moscow, Idaho 83843-4194. The University of Idaho is an EO/AA employer and educational institution.

Illinois Institute of Technology, Department of Electrical and Computer Engineering invites applications for tenure track and tenured faculty positions in the areas of computer, communication, electromagnetics, and power. Please send resume to Chair of Faculty Search Committee, Department of Electrical and Computer Engineering, Illinois Institute of Technology, Chicago, Illinois 60616. IIT is an equal opportunity/affirmative action employer.

Faculty Position—Ohio University: Applications are invited for a tenure-track faculty position with ■ specialty in control systems. The opening is immediately available. Duties include teaching at the graduate and undergraduate levels and obtaining and participating in sponsored research. Preference will be given to those candidates that have a demonstrated record or show potential for attracting externally supported research. Applicants must have ■ Ph.D. or equivalent. The position will be filled at the Assistant or Associate levels, depending on qualifications. The Electrical and Computer Engineering Department has the Stocker Endowment, worth more than $6 million, to support research and graduate education. The department is housed in the $12M Stocker Center and has more than $2.2M per year in sponsored research. The Department offers both the M.S. and Ph.D. degrees. To establish research programs, new faculty are given special consideration in terms of equipment budget and summer support. Ohio University provides competitive compensation. Screening of candidates will begin immediately, and applications will be accepted until the position is filled. Send a resume and the names of at least three reference to Dr. Dennis Irwin, Chairman of the Search Committee, Electrical and Computer Engineering Department, Stocker Center, Ohio University, Athens, Ohio 45701-2979. Preference will be given to U.S. Citizens and permanent residents. Ohio University is an equal opportunity and affirmative action employer.

The Department of Electrical Engineering at Tulane University invites applications for two nontenure track instructor positions. Some advantages are: 1) an excellent opportunity for a person with ■ masters degree in electrical engineering to prepare for ■ career in higher education while working toward the doctorate, 2) nine-month appointment with a salary reasonably competitive with industry, and 3) up to six hours of tuition free graduate study per semester. Existing research emphasizes signal and image processing, communications, control and power systems, and computer systems. Complete vitae, including official undergraduate and graduate transcripts and a minimum of three references, should be sent to Dr. S.T. Hsieh, Chairman, Search Committee, Department of Electrical Engineering, Tulane University, New Orleans, LA 70118-5674. Closing date is March 1, 1991. Tulane University is an equal opportunity/affirmative action employer.

North Dakota State University. The Department of Electrical and Electronics Engineering at North Dakota State University invites applications for tenure-track faculty positions. Applicants should show evidence of teaching and research ability and match departmental goals. They must hold ■ Ph.D. or equivalent by September 1, 1991 and communicate effectively in English. Assistant professor level preferred. Duties will include undergraduate and graduate teaching, research, and service. The department currently needs people in the following areas: (1) computer engineering (2) control systems, and (3) analog electronics. Exceptional applicants in other areas may also be considered. Applications with resume along with the names, addresses, phone numbers, and e-mail addresses (optional) of three references should be addressed to Dr. Noel W. Anderson, Faculty Search Committee, Department of Electrical and Electronics Engineering, P.O. Box 5285, North Dakota State University, Fargo, North Dakota 58105. Applications will be considered beginning December 1, 1990 and continuing until positions are filled. NDSU is an equal opportunity institution.

Chair in Photonic Systems. The Department of Electrical Engineering of McGill University is seeking an incumbent for ■ new Chair in Photonic Systems. Bell Northern Research and Northern Telecom Ltd., together with McGill University, will be seeking support for this Chair from the Natural Sciences and Engineering Research Council (NSERC) of Canada, through their Industrial Research Chair (IRC) program. Since this program is based on peer review, the successful candidate must be an internationally recognized authority, preferably working at the interface between photonic devices and systems, with outstanding scientific and leadership qualities that can bring the Department of Electrical Engineering to the forefront of research in Photonic Systems. An important condition for achieving this goal is the appointee's ability to build up a strong academic program for both graduate and undergraduate students. The position carries ■ highly competitive salary, junior faculty positions specifically designated in Photonic Systems, necessary laboratory space and, above all, strong University support for the above stated goals. Interested candidates are invited to send their resume to: Professor N.C. Rumin, Chairman, Department of Electrical Engineering, McGill University, 3480 University St., Montreal, QC, Canada, H3A 2A7. In accordance with Canadian Immigration requirements, this advertisement is directed in the first instance to Canadian citizens and Permanent residents of Canada. Applications from others are welcomed, however, consideration of their applications must be deferred until a Canadian search has been completed.

Carnegie Mellon: The Departments of Engineering and Public Policy and Electrical and Computer Engineering have ■ joint tenure track position for teaching and research on technical and policy issues in telecommunications policy; information policy; electronic industrial policy; or international security policy. Require Ph.D. and demonstrated research skills. Require policy aptitude and prefer demonstrated skills. Resume with references and writing sample to Prof. M. Granger Morgan, Head, EPP, Carnegie Mellon University, Pittsburgh, PA 15213. EO/AA employer.

Post Doctoral Fellowship: Department of Electrical and Computer Engineering, Ohio University, is seeking ■ Post Doctoral Research Associate in Bipolar VLSI Circuit Simulation. Salary range 20K to 24K US dollars for 12 months. Send resume and three letters of reference to: Dr. M. Ebrahim Mokari, Dept. ECE, Stocker Center, Ohio University, Athens, Ohio 45701. OU is an affirmative action/ equal opportunity employer.

San Diego State University (SDSU) invites applications for ■ tenure-track position in the Department of Electrical and Computer Engineering. The primary areas of interest are Control Systems and Power Systems. The position involves both research and teaching at the undergraduate and graduate levels. All levels of appointment will be considered. A Ph.D. in Electrical Engineering or a related field is required. SDSU is one of the largest Universities in California, offering over 150 different degrees. The ECE Department offers BS and MS degrees in Electrical Engineering, and has an enrollment of about 800 undergraduate and 150 graduate students. Send resume, by February 20, 1991 to Dr. L.R. Marino, Chair, Department of Electrical and Computer Engineering, San Diego State University, San Diego, California 92182-0190. San Diego State University is an Equal Opportunity/Affirmative Action/Title IX employer.

University of Central Florida (UCF); The Electrical Engineering Department (32 Faculty, 820 undergraduates, 280 graduate students) has ten-

ure/tenure-track openings in Communications, Digital Signal Processing, Digital/Analog Electronics, Electromagnetics, and Power, starting in the Fall of 1991. Rank and salary will be commensurate with qualifications. All applicants must have ■ Ph.D. at the time of employment and ■ strong commitment to teaching and research. Applications must be post-marked no later than February 1, 1991 and must be sent to: Dr. N.S. Tzannes, Chair, Electrical Engineering, University of Central Florida, Orlando, Florida 32816. UCF is an equal opportunity/affirmative action employer. An an agency of the State of Florida, all application materials and selection procedures are available for public review.

University of California, Davis Faculty Positions in Electrical Engineering and Computer Science. The Department of Electrical Engineering and Computer Science at UC Davis invites applications for various tenure track positions. The primary areas of interest are Computer Engineering and Microprocessor Application; Electronic Circuits; Image Processing and Computer Vision; and Optoelectronics. One position in the area of image processing and one in the area of optoelectronics. One position in the area of image processing and one in the area of optoelectronics is open to all ranks. Other positions are at the assistant professor level. The department, with 53 faculty members and 180 full-time graduate students, is experiencing rapid growth. Our College is the nation's sixteenth largest producer of engineering Ph.D.'s in a University which has the nineteenth largest extramural research funding. Salary and benefits are extremely attractive. Davis is a pleasant, family-oriented community near Sacramento, within easy driving distance to Silicon Valley, the Lawrence Livermore National Laboratory, San Francisco, the Pacific Ocean, and the Sierra Nevada Mountains. We are seeking individuals with strong records of teaching and research and with ambitious plans. Senior appointments require outstanding records of achievement; junior appointments must show evidence of great promise. All faculty are expected to have a strong commitment to teaching at all degree levels, and to demonstrate the ability to attract significant research support. The positions require a Ph.D. or equivalent, and are open until filled; but in order to assure consideration, applications should be received by March 1, 1991. Send a resume and the names of at least three references to: Professor S. Louis Hakimi, Chair, Attention: Faculty Search Committee, Department of Electrical Engineering and Computer Science, University of California, Davis, CA 95616. The University of California, Davis, is an equal opportunity/affirmative action employer.

Tennessee Technological University, Department of Electrical Engineering, invites applications for ■ tenure-track faculty position. The individual's primary emphasis should be in VLSI design with a strong background in electronics and digital systems. Three state-supported Centers of Excellence within the College provide a strong incentive for research. Candidates must have ■ Ph.D. in a relevant area and have abilities and interest in teaching at the undergraduate and graduate levels as well as conducting externally funded research in their area. Rank is negotiable but preference will be given to assistant professor. Screening process will begin February 15, 1991 and continue until filled. Submit resume and three references to Dr. G.M. Molen, Chairman, Electrical Engineering Department, Tennessee Technological University, Cookeville, TN 38505. TTU is an affirmative action/equal opportunity/TitleIX/Rehabilitation Act of 1973 employer.

The Purdue University School of Engineering and Technology at Indianapolis invites applications for several anticipated tenure-track positions at the Assistant/Associate Professor level in the areas of Computer Engineering and Signal Processing. Specific interests are in the areas of Medical Image Processing, Digital Signal Processing and Neural Networks, Robotics and Intelligent Machines with Vision and Sensor Applications, Communications Systems and Software Engineering. Applicants must hold an earned Ph.D. in Electrical Engineering or Computer Engineering. The positions offer unique opportunities to develop new capabilities in the areas mentioned and require a strong Commitment to teaching at the graduate and undergraduate levels and to the development of sponsored research. The School is currently developing interdisciplinary research efforts with the Indiana University School of Medicine, the second largest medical school in the country. Rank and salary are highly competitive and based upon experience and qualifications. Send resume with names an addresses of three references by January 31, 1991 to: Dr. A.S.C.Sinha, Acting Chairman, Department of Electrical Engineering, Purdue University School of Engineering and Technology at Indianapolis, 1201 East 38th Street, AD 157, Indianapolis, IN 46205-2868. The School of Engineering and Technology is one of the sixteen (16) schools of Indiana University-Purdue University at Indianapolis (IUPUI). IUPUI has an enrollment of over 28,500 students and 140 academic programs. The School of Engineering and Technology is an equal opportunity/affirmative action employer.

University of California at Berkeley—Faculty Positions In Control, Communications, and Low-Temperature Electronics, effective Fall Semester 1991, pending budgetary approval. The Department of Electrical Engineering and Computer Sciences at the University of California at Berkeley is currently seeking outstanding faculty candidates with research in the general areas of: (i) Nonconventional Computation for Control Systems. Areas of interest are application-specific computation systems where conventional computational techniques are inadequate such as encountered in large dynamical optimization problems, large computer aided control systems design problems, distributed real-time control systems or event driven dynamical systems. Candidates will be expected to teach undergraduate and graduate courses in the areas of linear and nonlinear control, optimization. (ii) Communication Systems. Areas of special interest include spread spectrum techniques, radio networks, personal and cellular networks and optical networks. Candidates will be expected to teach undergraduate and graduate courses in communication theory and estimation. (iii) Superconductive Electronics. Candidates might have interests in superconducting digital circuit design and/or device and fabrication technology for low and high-temperature superconductors. Candidates will be expected to teach undergraduate and graduate courses in semiconducting or superconducting devices, technology and/or circuits. Appointments will only be made at the Assistant Professor level in a tenure-track position. An applicant must have ■ doctoral degree or comparable academic and industrial experience. Interested persons should apply as soon as possible and by February 28, 1991, to the Chairman at the address listed below, including a resume, copies of publications, a statement of interest, and names and addresses of references. Candidates who applied earlier for positions (i) or (iii) should write reaffirming their interest, and may update their application, if desired. Professor Paul Gray, Chairman, Department of Electrical Engineering and Computer Sciences, University of California, Berkeley, California 94720. Telephone: (415) 642-0253. The University of California is an Equal Opportunity, Affirmative Action Employer.

The University of Kentucky invites applications for three tenure-track faculty positions in the Graduate Center for Biomedical Engineering. Areas of interest include signal/ image processing, control theory, instrumentation, biomechanics, and biomaterials. The candidates should have an on-going research program and a strong interest in teaching at the graduate level. Rank and salary are commensurate with experience. Applicants should submit ■ detailed curriculum vita with the names addresses of at least three references to: Search Committee, Center for Biomedical Engineering, Wenner Gren Research Laboratory, University of Kentucky, Lexington, KY 40506-0070. The deadline for applications is March 1, 1991.

University of Minnesota, Duluth, Assistant Professor, Experimental Solid-State Physics. The Department of Physics at the Duluth campus of the University of Minnesota invites applications for ■ tenure-track assistant professor position, for an experimental solid-state physicist, to begin September, 1991. Applicants should have ■ Ph.D. in physics or a related field and at least two years postdoctoral or equivalent experience. They should be committed to developing a strong research program as well as teaching graduate and undergraduate physics courses. They should be prepared to supervise master's thesis research and provide projects for undergraduate student research. Preference will be given to a physicist well versed in modern electronics whose research complements the department's existing experimental work in solid-state physics. Current activities involve photoreflectance studies of semiconductors and low-temperature scanning tunneling microscopy. Applicants should send curriculum vitae, and arrange to have three letters of recommendation sent, all prior to February 28, 1991, to: Professor Thomas F. Jordan, University of Minnesota, Duluth, Department of Physics, Duluth, Minnesota 55812. The University of Minnesota is an equal opportunity educator and employer and specifically invites and encourages applications from women and minorities.

The Department of Electrical Engineering at the University of California, Los Angeles is involved in a major expansion of its instructional and research facilities in ■ new engineering building. In addition, an expansion is planned in tenure track faculty positions. Applications are being accepted in the following areas of expertise: Optoelectronics, Optical Signal Processing, Microwave and Millimeter Wave Electronics, Electromagnetics, VLSI Systems, Integrated Circuits and Signal Processing, Coding/Modulation/Digital Communication and Data and Image Compression. Applicants should have a PhD and an outstanding research record in their expertise. Application letters should be mailed to Professor Nicolaos G. Alexopoulos, Chairman, Electrical Engineering Department, UCLA, 58-121 Engr. IV, 405 Hilgard Ave., Los Angeles, CA 90024-1594. UCLA is an Equal Opportunity Affirmative Action Employer.

Stanford University invites applications for a senior, tenure line faculty member in manufacturing. We are looking for an individual who can provide leadership in the development of manufacturing research and teaching. Experience and accomplishments in the academic world must be of such an extent and quality that would qualify the individual for appointment to a chaired position. The individual would participate in teaching and research activities associated with the programs in manufacturing. In addition, he or she would be expected to play a key leadership role in the School of Engineering's manufacturing activities and in the Stanford Integrated Manufacturing Association. A background that would allow the individual to span manufacturing technology and manufacturing management would be desirable. The position, as now defined, is in the School of Engineering; however, there is the possibility of an appropriate joint appointment with the Graduate School of Business, and the search committee is made up of faculty from both schools. Stanford University is an affirmative action employer and welcomes applications from women and ethnic minority candidates. Applications should be submitted before February 1, 1991, to the Chairman of the Manufacturing Leadership Search Committee, SIMA, School of Engineering, Building 530, Stanford University, Stanford, CA 94305-4028.

University of Notre Dame, Chairperson, Department of Computer Science and Engineering. The University of Notre Dame invites applications for the Chair of the recently established Department of Computer Science and Engineering in the College of Engineering. This position is a unique opportunity to provide significant input in establishing direction for the initiation and growth of programs in this department. Persons with established records in education and scholarship who would welcome the challenge of developing a new department and its programs are encouraged to apply. The faculty of the department is expected to determine the curricula leading to graduate and undergraduate degrees in computer science and in computer engineering. The Department of Computer Science and Engineering has twelve tenure-track faculty positions. The Department of Electrical Engineering and its present graduate and undergraduate options of emphasis in computer engineering are expected to provide the foundation for the programs in the new department. It is anticipated that the Department of Computer Science and Engineering will have close cooperative ties with the Department of Electrical Engineering, Department of Mathematics, and other academic units. Qualified applicants are encouraged to submit a resume and letter of interest to: Dr. Panos J. Antsaklis, Department of Electrical Engineering, University of Notre Dame, Notre Dame, IL 46556. For additional information, please contact the

Dean's office at (219) 239-5534. The University of Notre Dame invites applications from all qualified persons without regard to sex, ethnic origin, religious preference or physical impairment.

Stanford University: The Mechanical Engineering Design Division invites applications for a tenure-track position in programmable-electromechanical-systems design. The appointment is available at the assistant professorship level. The successful candidate will have demonstrated ■ creative achievement record in the practice of design and/or the study of design theory and methodology. Particular attention will be given to qualifications required for a leadership position in Stanford's Smart Product Design curriculum (mechatronics). Concern for human values, aesthetics, and interdisciplinary collaboration will be welcome. Industrial experience is desirable. A research program plan is essential. Please send a letter of introduction, resume and exemplary material to Professor Larry Leifer, Design Division, Mechanical Engineering, Stanford University, Stanford, CA 94305-4021. Stanford is an equal opportunity/affirmative action employer.

Electrical Engineering Faculty. The School of Science & Engineering invites applications from individuals who have ■ strong interest in teaching graduate and undergraduate courses, conducting research, and interacting with industry to join its expanding electrical engineering program. The School, known for its strong design and application components, houses exceptionally attractive state-of-the-art facilities. New laboratories for CAD/CAE, Hybrid Microelectronic, Thick & Thin films, Microwaves & Antennas, and ■ new computer center have just been completed. Candidates should have a solid engineering background. Preferred areas of interest are: Computer Engineering and Analog and Digital Electronics. Experience with engineering design software packages is very important. Ample opportunities are available for professional growth and interaction with an active and collegiate faculty supervising ■ variety of funded projects. Wilkes is in close proximity to the industrial and cultural centers of Boston, New York, Philadelphia, and Washington, D.C., and has well established working relationship with the local industries. Faculty members are encouraged to establish strong ties with industry and national laboratories. The location is also close to the recreational facilities of the Pocono Mountains. Candidates for the positions should have an earned Ph.D. or be in the final stages of the degree. A complete resume (include citizenship or visa status and three references) should be submitted to: Dr. Brian Redmond, Associate Dean, School of Science & Engineering, Wilkes University, Wilkes-Barre, PA 18766. Women and Minorities are encouraged to apply. AA/EEO.

Faculty Position in Statistics And Engineering. Tenure track position in Statistics and Engineering, Iowa State University. This new position will be ■ joint appointment between the ISU Statistics Department and an appropriate department in the ISU College of Engineering. Duties will include interdisciplinary teaching and research. A Ph.D. in either Statistics or Engineering, and interest in both areas is required. Degrees in both Statistics and Engineering preferred. Previous teaching, consulting and/or industrial experience is also desirable. Some preference will be given to candidates with Electrical or Mechanical Engineering background. A letter of application, resume and three letters of reference should be sent directly to: Professor Steve Vardeman, Co-Chair, Statistics and Engineering Faculty Search Committee, Department of Statistics, Iowa State University, Ames, Iowa 50011. Recent Ph.D's should also include graduate and undergraduate transcripts.

Electrical Engineers, Louisiana State University-CAMD. The J. Bennett Johnston, Sr. Center for Advanced Microstructures and Devices (CAMD) at LSU seeks one Senior and one Junior Electrical Engineer. Requires B.S. in Electrical Engineering; experience in the areas of high current DC power supplies, CW and pulsed klystron systems, pulsed high voltage power supplies; experience with modern diagnostics equipment, like spectrum and network analyzers. Knowledge in the design, fabrication and commissioning of digital and analog electrical and electronic systems is desired. A letter of application, a resume, and three references should be sent to: Dr. B.C. Craft, The J. Bennett Johnston, Sr. Center for Advanced Microstructures and Devices, Louisiana State University, 3990 West Lakeshore Drive, Baton Rouge, LA 70803. The deadline for applications is February 1, 1991. LSU is an Equal Opportunity University.

Drexel Fellowships In Biomedical Engineering And Science. Drexel Fellowships in Biomedical Engineering and Science are supported by the Calhoun Endowment. Students can specialize in the following areas: artificial organs, bioinstrumentation, biomedical imaging and signal processing, biomedical science, biomaterials, biomedical systems and control, cardiovascular dynamics, diagnostic ultrasound, sensors and electrodes, biomechanics and rehabilitation. Each Fellowship includes a minimum stipend of $10,000 for ■ 12 month appointment beginning Fall, 1991. With a waiver of all tuition and fees this award is worth approximately $22,000. Deadline for application is February 28, 1991. For application write: Dr. Dov Jaron, Director, Biomedical Engineering and Science Institute, Drexel University, Philadelphia, PA 19104.

California Institute of Technology. The Computation and Neural Systems (CNS) program at Caltech is conducting a search for a tenure-track Assistant Professor on the engineering side of CNS, for which the term of initial appointment is normally four years. CNS is an interdisciplinary Ph.D. program established in 1986 that brings together engineers and scientists who are applying ideas from neurobiology to the development of new computational devices and systems and biologists who are investigating how computation is done in the nervous system. Areas of interest include Motor Control, Learning, Speech, Vision and Artificial Neural Networks. The appointee will be expected to develop ■ strong research activity, and to teach courses in his or her specialty. Applicants should send a resume, including list of publications, a brief statement of research accomplishments and goals, and the names of at least three references to Professor Y. Abu-Mostafa, Caltech 116-81, Pasadena, CA 91125. Caltech is an equal-opportunity employer and it specifically encourages women and minorities to apply.

Purdue University School of Electrical Engineering invites applications for tenure-track faculty positions at all ranks. Primary need is for faculty with specialization in the areas of computers, microelectronics, and optics; but all specialties will be considered. Responsibilities will include both teaching and research. Salary is commensurate with qualifications and experience. Applicants must possess a doctorate degree. Send a resume, including a statement of teaching and research interests and ■ list of three (3) references, to: Head, School of Electrical Engineering, Purdue University, West Lafayette, IN 47907. Purdue University is an Equal Opportunity/Affirmative Action employer.

The Swiss Federal Institute of Technology (ETH Zurich) invites applications for a faculty position in Electronics. Duties associated with the position include research in the field of electronic circuit design and teaching at undergraduate and graduate levels. Of particular interest are analog devices, the design of analog circuits and A/D converters and their application, e.g. in the metrology and sensor technology. The candidate should have profound experience in engineering and research in the area of integrated circuits design, modeling and related simulation tools. Cooperation in teaching and research with other colleagues in the Department of Electrical Engineering as well as with manufacturers of integrated circuits is also expected. Applications including curriculum vitae, a short description of research interests as well as a list of publications and patents etc. should be submitted before January 31, 1991, to Prof. Dr. J. Nuesch, President of ETH Zurich, ETH-Zentrum, CH-8092 Zurich.

Electrical/ Computer Faculty Positions. The Department of Electrical and Computer Engineering at LSU invites applications for anticipated tenure-track and visiting faculty positions available August 1991 in the following areas: electric energy systems, including power electronics; solid state electronics; systems, including automatic control, communications and signal processing; and computers, including microprocessors, distributed processing systems and special purpose architectures. A PhD or equivalent and potential for excellence in teaching and research are necessary. Rank is open. Salary is competitive and commensurate with qualifications and experience. Release time and resources are provided in order to enhance the development of ■ quality research program. Opportunities for summer support are available. Send resume, names of three references, ■ statement of teaching and research interests, and verification of employment eligibility in compliance with the Immigration Reform and Control Act of 1986 to: Alan H. Marshak, Chairman, Electrical and Computer Engineering, Louisiana State University, Baton Rouge, LA 70803-5901. LSU is an Equal Opportunity Employer.

University Of California at Berkeley. Faculty position in Microelectronics effective Fall Semester 1991, pending budgetary approval. The Department of Electrical Engineering and Computer Sciences at the University of California at Berkeley is currently seeking outstanding faculty candidates with research in the general area of Microelectronic Circuits. Candidates might have interests in VLSI circuits for analog and digital signal processing, analog/digital conversion, wideband communications, sensor and transducer interfaces, high speed digital processing, and related areas. Candidates will be expected to teach undergraduate and graduate courses in the area of electronic circuits. Experience in industry is desirable. Preference will be given to appointment at the Assistant Professor level in ■ tenure-track position, but appointment at the tenure level may be possible for an exceptionally qualified and experienced candidate. All applicants must have a doctoral degree or comparable academic and industrial experience. Interested persons should apply as soon as possible and by February 28, 1991, to the Chairman at the address listed below, including a resume, copies of publications, ■ statement of interest and names and addresses of references. Professor Paul Gray, Chairman, Department of Electrical Engineering and Computer Sciences, University of California, Berkeley, California 94720. Telephone: (415) 642-0253. The University of California is an Equal Opportunity, Affirmative Action Employer.

Electrical/Controls Engineer. The University of Iowa Physical Plant is looking for ■ plant engineer with the skills and experience to perform engineering work for the repair and modification of campus utilities and buildings including: production and distribution of steam, electricity, and chilled water; energy management systems; building heating ventilation and air conditioning systems and their controls. The Plant Electrical/Controls Engineer requires: three to five years of Electrical/Controls engineering experience in one or more of the areas listed above; ■ college degree in engineering or equivalent experience and education; knowledge of buildings and national electrical codes; design ability in direct digital HVAC control systems; remote electronic energy metering and DDC boiler controls. This position requires good interpersonal skills, including tact, flexibility, and both oral and written communications. The University of Iowa is a nationally recognized learning and research center. This Big Ten University, with over 11 million GSF of buildings, and an extensive utilities infrastructure, is located along the Iowa River in an attractive community. Interested candidates should send a letter of application and ■ resume to Jon H. McLeod, University of Iowa Physical Plant, 103 W. Burlington, Iowa City, IA 52242. Applications will be accepted until the position is filled. The University is ■ affirmative action/equal opportunity employer.

Title: Assistant Research Engineer. As Assistant Research Engineer, participate in a DOE-funded fusion reactor research project focusing on environmental, safety and economic aspects of fusion reactor design; including extensive computer calculations of radioactive inventories in various reactor designs, calculations of dose, safety analysis, waste management assessment, and data management to apply this information to future designs. Duties

include assisting Principal Investigator in managing the research group. Qualifications Required: A Ph.D. degree or equivalent in Nuclear Engineering or related field, and demonstrated competence with large scale computer calculations. Direct research experience in the areas of environmental safety, and economic aspects of fusion reactors is preferred. Salary Range: $51,300 to $64,400/year, depending on qualifications. Approximate Starting Date: January 15, 1991. Application Deadline: December 31, 1990 or 30 days from publication date, whichever is later. Apply to: Send curriculum vitae and name/address of three references to: Dr. T.K. Fowler, Chair, University of California, Berkeley, Department of Nuclear Engineering, 4153 Etcheverry Hall, Berkeley, California 94720. Telephone: (415) 642-5010. The University of California is an equal opportunity, affirmative action employer.

Dean, College of Engineering, The University of South Alabama. The University of South Alabama College of Engineering invites applications and nominations for the position of Dean of the College of Engineering. The College of Engineering consists of 30 faculty members in four departments: Chemical, Civil, Electrical and Mechanical. The College offers undergraduate programs in each of those disciplines and Master's programs in ChE, EE and ME. The College enrollment is approximately 1100 students. The University of South Alabama is a 25 year old, state supported institution in Mobile, a mid-sized, historic city thirty miles from the white sand beaches of the Gulf of Mexico. Mobile serves as the commercial, medical and educational center for the region. The University of South Alabama enrollment is approximately 12,000 and degrees are awarded at the Baccalaureate, Master's, M.D. and Ph.D. levels. The University is a primary contributor to the region's quality of life and economic vitality. The Dean of the College of Engineering provides the academic, administrative and intellectual leadership for the College and reports directly to the Vice President for Academic Affairs. The Dean is responsible for maintaining and developing all aspects of the College's instructional, research and service programs. Qualifications: Candidates must meet the following requirements: 1. A record of teaching and scholarship commensurate with the appointment as full professor in a department in the college. 2. Commitment to engineering education including excellence in teaching and scholarly activity. 3. Demonstrated leadership and successful academic administrative experience. 4. Ability to work and communicate effectively with students, faculty, administrators and external constituencies. Appointment effective no later than September, 1991. Salary is competitive. Application deadline is February 1, 1991. Send curriculum vitae and names, addresses and telephone numbers of three references to: Dr. Wilford D. Raburn, Chairman Search Committee, Department of Electrical Engineering, University of South Alabama, Mobile, AL 36688. PH: (205) 460-6117. The University of South Alabama is an Affirmative Action/Equal Opportunity Employer.

Department of Systems Engineering, University of Virginia. Applications are invited for tenure-track appointments at all professorial levels in the Department of Systems Engineering. Positions may become available early as January 1991. Applicants should have an interdisciplinary orientation with strong research and teaching interests, particularly in quantitative methods. Research experience or a demonstrated potential in one or more of the following areas is desirable: combinatorial optimization, heuristic search, decision aiding, machine learning, and uncertain approximate reasoning. The positions offer teaching opportunities at the undergraduate, masters, and Ph.D. levels. Currently the department enrolls approximately 220 undergraduates and 60 graduate students. The faculty is highly active in contemporary research issues dealing with knowledge-based systems, decision and control theory, optimization and search, applied probability, and statistics, discrete event dynamic systems, simulation, and engineering management. The department takes a strongly analytic approach often with a mission orientation in its research. Send resume, and the names, addresses and telephone numbers of at least three references to Professor Furman W. Barton, Chairman, Department of Systems Engineering, University of Virginia, Charlottesville, VA 22903 as soon as possible but by 1 February 1991 at the latest for a September 1991 appointment. The University of Virginia is an Equal Opportunity, Affirmative Action Employer.

The School of Engineering Science at Simon Fraser University invites applications for a tenure-track faculty position in Microelectronic Sensors and Actuators. The position requires dedicated teaching at both the graduate and undergraduate levels, as well as strong research abilities. The candidate will hold an earned Ph.D. in Microelectronics or Microelectronic Sensors and have expertise in the current technology of Silicon Micromachining. An outstanding research potential and demonstrated research capability in one or more of the following areas is required: design of analog and digital integrated circuits using CMOS technology; fabrication of semiconductor devices including integrated sensors and actuators; VLSI materials and devices; VLSI system design, modelling, simulation and verification. The candidate should be well versed with CMOS IC design using "silicon foundry" facilities. Engineering Science provides an exciting educational environment demanding high academic standards of its students. Local industry offers many opportunities for faculty research and strong industrial links are characteristic of the program. This academic environment is balanced by the natural and cultural ambience of one of the most attractive cities in North America. Moreover, the university itself enjoys a spectacular mountaintop setting, a short drive from downtown Vancouver. This advertisement is directed to people who are eligible for employment in Canada at the time of application. Applications from candidates not presently eligible for employment in Canada are welcomed but consideration of such candidates must be deferred until a Canadian search is complete. Positions are subject to budgetary authorization. To apply, send a curriculum vitae and the names of three references to Dr. James K. Cavers, Director, School of Engineering Science, Simon Fraser University, Burnaby, B.C. V5A 1S6, Canada. Simon Fraser University is committed to the principle of equity in employment and offers equal employment opportunities to qualified applicants.

The Center for Advanced Computer Studies. The Center is seeking qualified candidates for tenure track research faculty positions in Computer Science/Engineering, beginning Fall 1991. Associate Professor and Professor candidates must hold PhDs in the field, and have established research publications and grant records. Exceptional Assistant Professor candidates will also be considered, must hold Ph.D.s in the field, and must have strong research potential. Consideration will be given to all qualified candidates, but preference areas of interest are: software engineering, computer networks, operating systems, databases, computer architecture, artificial intelligence, and theoretical computer science. The Center conducts programs leading to the MS/PhD degrees in Computer Science and Computer Engineering. These programs currently enroll 210 students, with approximately 100 declared PhD candidates. A large number of PhD fellowships and assistantships available, with stipends of up to $18,000 per year, up to 4 years. Typical faculty teaching load is 2 courses per year and a continuing research seminar, with solid travel support. Substantial State Educational Fund monies available to establish research programs. The University is located in Acadiana, a short distance West of New Orleans. Send resumes to: Dr. Michael C. Mulder, Director, The Center for Advanced Computer Studies, University of SW Louisiana, P.O. Box 44930, Lafayette, LA 70504; email: cathy@cacs.usl.edu. Review of applications will begin February 1991. The University of SW Louisiana is an affirmative action/equal employer.

Chairperson, Department of Electrical Engineering, Howard University, Washington, D.C. Applications and nominations are being received for the position of Chairperson in the Department of Electrical Engineering at Howard University in the Fall, 1991. The department is ABET accredited and offers BS, MS and Ph.D. degrees with areas of concentration in Energy Systems and Controls, Communications, Solid State, Digital Systems, and Microwaves to approximately 400 undergraduate and 65 graduate students. The department has several research facilities including Solid State, Energy Systems, Digital and Signal Processing Laboratories and 18 full-time faculty members. Qualifications: A doctorate degree in electrical engineering, experience as a faculty member (at least associate professor level) in ABET accredited EE program and departmental administration, interest in quality undergraduate and graduate programs, research, and fostering of extramural funding research, continued development of the university community, recruiting of new faculty members and students, and strong leadership with a commitment to excellence. Howard University is an equal opportunity employer. Send resumes and three references, including telephone numbers by March 10, 1991 to: Howard University, The Chairman Search Committee, Department of Electrical Engineering, Washington, D.C. 20059.

University of Wisconsin-Platteville. The Department of Electrical Engineering anticipates two openings and invites applications for tenure track faculty positions at the assistant/associate professor level. A strong commitment to undergraduate engineering education is essential. Professional development including research is encouraged. Qualifications required Ph.D. in electrical engineering or a master's degree and significant industrial experience. One position is in the control and is available Spring 1991. The other is in the digital/computer area and is available Fall 1991. The ideal candidate for the control area position would also have some background in power engineering. Located in southwest Wisconsin, Platteville provides a small town environment with the convenience of two urban close by. Send resume and references to Dr. Richard Shultz, Chairman, Electrical Engineering Department, University of Wisconsin-Platteville, 1 University Plaza, Platteville, WI 53818-3099. An equal opportunity/affirmative action employer.

Electrical Engineering: Tenure track position available July 1, 1991 at the assistant professor level (higher rank considered based on experience). We are looking for someone with background in power systems and/or electromechanical energy conversion. A strong commitment to undergraduate teaching is essential as is a desire to become involved in our broad-based lab oriented curriculum. Ph.D. preferred but will consider M.S. with significant relevant experience. U.S. citizenship or permanent residency strongly preferred. Norwich University is located in an of central Vermont that offers small-town or rural living with good schools and outstanding recreational opportunities. Send resume and references to: Prof. William Till, Chairman, Dept. of Electrical Engineering, Norwich University, Northfield, VT 05663. Position open until filled. EOE, women encouraged to apply.

Scripps Institution of Oceanography invites applications for a postgraduate researcher in digital image analysis/remote sensing, for up to two years with the possibility of extension, beginning 1 May 1991 or soon thereafter. The position will involve the development and of digital image analysis methods to study geophysical processes observed from earth-observing spacecraft. A Ph.D. or equivalent degree in computer science, electrical engineering, remote-sensing, or a related field is required. Knowledge of UNIX, C, and experience with digital image analysis/signal processing techniques is desirable. Salary ranges from $29,844 to $31,212, commensurate with experience. Applicants should submit a curriculum vitae, including the names of at least three references, to: University of California, San Diego, Chairperson, Search Committee, Scripps Institution of Oceanography 0230, La Jolla, CA 92093-0230, by 1 February 1991. The University of California, San Diego is an Equal Opportunity/Affirmative Action Employer.

Faculty. Department of Electrical and Computer Engineering, Florida International University, A State University of Florida at Miami. Nominations and applications are invited for senior tenure track faculty positions in microelectronics, computer engineering, and electrical engineering. The Department of Electrical and Computer Engineering at F.I.U. is relatively (1982), has 16 faculty, 400 students, offers B.S. (accredited) and M.S. degrees in both electrical and computer engineering, (Ph.D. is in planning), and is now housed in our new building (95,000 sq. ft.). Qualifications: Earned doctorate with strong record of funded research, preferably from government agencies, desire to direct and assist young faculty in obtaining funded research.

Also evidence of substantial good experience in other scholarly areas, including publications and teaching. Rank and salary are commensurate with qualifications and experience. Applications and Dates: All applications received prior to February 7, 1991, will receive full consideration. The positions will be available starting August, 1991. U.S. citizens or lawfully authorized alien workers should send a letter addressing the qualifications above, a resume, and three references (names) to: Dr. Wunnava V. Subbarao, Chair, Search and Screen Committee, Department of Electrical and Computer Engineering, Florida International University, Miami, FL 33199. Florida International University is a state university located in two suburban areas in Miami with over 22,000 students, of which 1,400 are enrolled in the College of Engineering and Design. The School of Engineering has four departments: Electrical and Computer, Civil, Mechanical, and Industrial Engineering and is an Equal Opportunity/Equal Access Employer and Institution.

Carnegie Mellon International Peace and Security: Candidates with strong backgrounds in engineering or the physical sciences are sought for a tenure track faculty position in the Department of Engineering and Public Policy (and perhaps a second technical department) to teach and do research on problems in arms control and international security policy in which technical issues are of central importance. Send resume, references, and sample papers to Prof. Granger Moran, Head, EPP, Carnegie Mellon, Pittsburgh, PA 15213.

Penn State, College of Engineering: A New Center for Teaching Innovation. The College of Engineering invites applications and nominations for the Director of the Leonhard Center for Innovation and Enhancement of Engineering Education. The Center will assist the College in developing: innovation for more effective teaching and learning; Leadership and communication skills in students; Student interest in careers in teaching and research. The Leonhard Center will be recently established through a deferred gift from Mr. William Leonhard, retired Chairman and CEO of the Parsons Corporation in Pasadena, California. He is a distinguished Penn State alumnus and a member of the National Academy of Engineering. The Director who should have academic credentials for a faculty position and a background in engineering and pedagogy, should have an intense interest in teaching and learning and should be innovative. The Director will report directly to the Dean and will work closely with faculty, staff and students. The Director should possess good organizational and interpersonal skills and have a strong entrepreneurial spirit. The position will be filled as soon as the successful candidate is available. Nominations and applications, including curriculum vitae, received by February 28, 1991, will be assured of consideration. However, applications will be considered until position is filled. Inquiries and applications should be directed to: Carl H. Wolgemuth, Chairman, Leonhard Center Director Search Committee, Box IEEE, 101 Hammond Building, University Park, PA 16802. An Affirmative Action/Equal Opportunity Employer. Women and Minorities Encouraged to Apply.

Post-Doctoral Fellow and Ph.D. Students—The Communication Sciences Laboratory at Simon Fraser University in Greater Vancouver has a post-doctoral opening and full financial support for Ph.D. students for research in joint speech and channel coding for digital mobile communications. Candidates applying for the post-doctoral position must have extensive research experience in at least one of the following areas: speech coding, channel coding and modulation, and mobile communications. Candidates applying as doctoral students should have a Masters Degree from a recognized university, and have relevant experience in the general area of digital communication and signal processing. To apply, please send a resume, with names and addresses of three referees to Dr. Paul Ho (re: adv), School of Engineering Science, Simon Fraser University, Burnaby, B.C., Canada, V5A 1S6.

Rice University Department of Electrical and Computer Engineering invites applications for faculty positions in the areas of robotics, signal processing, and computer systems. Applicants in the area of robotics should be interested in space or undersea applications and be able to lead a robotics laboratory. Applicants in signal processing should have a background in basic signal and systems with interests in image and multidimensional processing. Applicants in the computer systems area should have interests in the general areas of computer architecture, operating systems, and parallel computing. Outstanding applicants working in related areas will also be considered. Rice University is a small, private university with a long history of excellence in both research and teaching. It is located in Houston, Texas, a clean modern city with affordable housing and excellent fine arts. The Department of Electrical and Computer Engineering has close ties with the Computer Science Department, Mathematical Sciences Dept. and the Mechanical Engineering Department, all being in the School of Engineering. The Robotics Laboratory has excellent facilities and research ties with NASA as well as other groups. The Computer Systems Laboratory provides research focus in computer architecture, operating systems, parallel algorithms, software, performance evaluation, VLSI design, and other related areas. The Signal Processing Group has a long history of research in algorithms, filter design, statistical signal processing, and biomedical applications. Rice has an NSF funded Science and Technology Center for Research on Parallel Computation that provides facilities and coordination for all groups. Applicants should submit their resume, a summary of their research accomplishments, and the names of at least three references to the Chairman of the Department of Electrical and Computer Engineering, Rice University, P.O. Box 1892, Houston, TX 77251-1892. Rice University is an equal opportunity/affirmative action employer.

University of Arkansas, Electrical Engineering Faculty Position. The Department of Electrical Engineering, University of Arkansas, has a faculty position available August 1991 in the area of microprocessors/microcontrollers/DSP hardware. Applicants must have an earned doctorate. Duties include undergraduate and graduate teaching and research. Send applications including a list of references to Head, Department of Electrical Engineering, University of Arkansas, Bell Engineering Center 3217, Fayetteville, Arkansas 72701. Applicants must have proof of legal authority to work in the United States. The University is an Equal Opportunity/Affirmative Action Employer.

Electrical Engineering/ Electro-Optics: The University of Dayton invites applications for a tenure-track faculty position. The Department of Electrical Engineering is seeking an individual with an earned doctorate to teach and perform research in the areas of electrical engineering and electro-optics, ideally with an emphasis on systems. The Department currently offers the bachelors, masters and doctorate degrees in electrical engineering and is involved with an established cross disciplinary electro-optics masters degree program which was chosen seven years ago by the university to be an area of excellence. Teaching duties would be at the undergraduate and graduate levels. Also, it is anticipated that the applicant will be capable of contributing to established long-term, sponsored electro-optics research programs of national prominence. U.S. citizenship or permanent residency is preferred. Salary and starting date are negotiable with the latest starting date being August 16, 1991. Send vita and the names and addresses of three references to: Dr. Don Moon, Chairman, EE Dept., University of Dayton, 300 College Park, Dayton, OH 45469-0226. UD is an EEO/AA Employer.

Biomedical Engineer. The new Department of Biomedical Engineering at the University of Tennessee, Memphis is seeking to fill a tenure-track faculty position in the area of biomedical modelling at the assistant or associate professor level. In addition to teaching and research in the Department, the successful candidate will serve as a core faculty member in The Center for Pediatric Pharmacokinetics and Therapeutics, one of three centers of excellence designated for the UT Memphis campus. Additional opportunities for collaboration exist in areas such as pharmacodynamic modelling, nuclear medicine imaging, binding of cardiac antiarrhythmic drugs, and pharmacokinetics of anticancer drugs. In addition to an earned doctorate in biomedical engineering, biomathematics, or a related field, it is anticipated that the successful candidate will either have demonstrated experience in pharmacokinetic and pharmacodynamic modelling or will have formal training and expertise in advanced techniques for modelling, estimating and control of complex systems, and a genuine interest in pharmacokinetics. Interested applicants should send a CV and the names of three references to Jack Buchanan, MSEE, MD, Associate Professor and Chair of Search Committee, Department of Biomedical Engineering, 801 Baptist Hospital, 899 Madison Avenue, Memphis, TN 38163. Telephone (901) 528-7099. The closing date for receiving applications is February 28, 1991; however, the University reserves the privilege of accepting late applications. The University of Tennessee, Memphis is an Equal Employment Opportunity/Title IX/Section 504/ Affirmative Action Employer.

Lehigh University—The Department of Computer Science and Electrical Engineering is seeking applications for a tenure track position in Electrical or Computer Engineering at the rank of Assistant or Associate Professor. A doctorate degree in electrical or computer engineering, an outstanding academic record and evidence of effective teaching ability are required. The applicant is expected to participate in the planning, development, and teaching of the core undergraduate courses and laboratories. These core areas include circuits and systems, signal processing, circuit design, communications, controls, and machines. The applicant is expected to have demonstrated capability of scholarship of highest quality, and will be expected to develop an active research program. Potential for securing funded research will be an important consideration in the selection process. US citizenship or permanent US residency are preferred. Lehigh University is an Affirmative Action employer, and welcomes applications from women and minority candidates. Applications should be sent to Prof. F.H. Hielscher, CSEE Department, Packard Laboratory #19, Lehigh University, Bethlehem, PA 18015.

Southern Illinois University at Carbondale. The Department of Electrical Engineering invites applications for two tenure-track faculty positions at all ranks in the following areas: (1) Digital Systems/Computer Engineering and (2) Artificial Neural Networks/ Neuroengineering. Qualifications for appointment include a Ph.D. in Electrical Engineering or a related field, and a strong documented commitment to research. Individuals currently working toward their Ph.D. degree and expecting to graduate by August 16, 1991 will be considered for interview. The department has an enrollment of 600 undergraduate and 150 graduate students, and a faculty of 23. Laboratory and computer facilities are excellent. Faculty in the Department of Electrical Engineering, in addition to teaching undergraduate and graduate courses, are expected to develop successful research programs in their respective areas of interest. The department provides support and excellent opportunities for the development of new faculty. Applications should include a resume, list of three references, and a statement of goals to: Chair of Search Committee, Department of Electrical Engineering, Southern Illinois University at Carbondale, Carbondale, Illinois 62901-6603. Consideration of applications will begin January 3, 1991 and will continue until positions are filled. Minorities and women are strongly encouraged to apply. SIUC is an equal opportunity, affirmative action employer.

Rensselaer Polytechnic Institute, Department of Electrical, Computer, and Systems Engineering, invites applications for tenure-track faculty positions at all levels. Specific areas of interest include: (1) optical communications and networks; optical computing; (2) computer engineering and architecture, especially real-time systems and neural networks; (3) discrete-event systems and Petri net analysis with applications to manufacturing and networks; (4) plasma diagnostics and electromagnetics with an emphasis on active particle beam based diagnostics for magnetic confinement experiments. The ECSE Department is the largest academic unit at RPI and has a rich tradition of research and education. The department is seeking to

add faculty who bring an innovative approach to research and teaching. Active programs in computer engineering, solid-state electronics and integrated circuit design, control systems, robotics and automation, information and decision systems, communications and signal processing, electronics and circuits, and fusion plasma systems contribute to ■ dynamic research environment. In addition to the extensive research facilities of the department, there are opportunities to initiate or participate in interdisciplinary research programs in one of the major research centers of the School of Engineering, including the Center for Integrated Electronics, Rensselaer Design Research Center, Center for Manufacturing Productivity and Technology Transfer, the NASA Center for Intelligent Systems in Space Exploration and the New York State Center for Advanced Technology and Robotics. New faculty are eligible for special arrangements including summer support, equipment, graduate student support, and reduced teaching load in order to encourage growth of their research programs. Applications or request for more information should be directed to: Dr. Arthur C. Sanderson, Chairman, Dept. of Electrical, Computer and Systems Engineering, Rensselaer Polytechnic Institute, Troy, NY 12180-3590. RPI is an affirmative action/equal opportunity employer and encourages applications from women and minorities.

The Laboratory of Nuclear Studies at Cornell University has an opening for a Physicist/RF Engineer Research Associate to participate in Microwave Superconductivity R/D directed at application to high energy physics electron-positron colliders. PhD in Physics or Engineering, or advanced degree with equivalent experience required. Experience in RF, accelerator physics, or accelerator technology highly desirable. Salary commensurate with experience. Apply by letter to H. Padamsee, Newman Laboratory, Cornell University, Ithaca, NY 14853. Cornell is an Equal Opportunity Employer.

San Francisco State University seeks applications for tenure-track faculty position in power systems and power electronics Candidates for position must have earned ■ Ph.D. in electrical engineering, and possess proficiency in using digital computers for analysis and design of power systems and power electronic circuits, and have a strong interest in teaching as well as professional activities. Industrial experience is desirable. Rank and salary commensurate with experience. Send resume, and ■ list of three references to: Dr. M. Abo-El-Ata, Division of Engineering, San Francisco State University, 1600 Holloway Avenue, San Francisco, CA 94132. Closing date for application is March 1, 1991. Applications may be accepted at ■ later date if the position has not been filled.

Harvey Mudd College. Fletcher Jones Chair in Engineering Design. Applications are invited for this newly endowed senior-level tenure track position in the Engineering Department. Appointment at the full professor level is anticipated. Professional background and experience must include familiarity with modern computer-aided design concepts and leadership of multidisciplinary design projects. The successful candidate will lead the development of the department's new Engineering Design Center. Additional responsibilities will include teaching in ■ unified curriculum and supervision of industrially sponsored projects through the Engineering Clinic. Active involvement in the advancement of the discipline of engineering design is expected. Excellent opportunities for consulting and other professional activities exist in the local area. A Doctorate or equivalent qualification is required. Applications with a complete resume and the names, mailing addresses, and telephone numbers of three references should be sent to Engineering Design Search, Attention: Professor John I. Molinder, Chairman of Engineering, Harvey Mudd College, Claremont, CA 91711 by March 1, 1991. Harvey Mudd College is an equal opportunity/affirmative action employer.

Graduate Fellowships and Research Associates. Fellowships and Associateships are available for M.S. or Ph.D. students in Electrical Engineering. Fellowships provide ■ nine-month stipend of $15,000 for Ph.D. students and $12,000 for M.S. students plus tuition waiver. The stipend for Research Associates is $8,000 for nine months plus tuition waiver, and requires research duties under the direction of ■ faculty member. Applicants must be U.S. citizens and possess ■ B.S.E.E. or M.S.E.E. from an engineering department that has ■ basic or advanced program that is ABET accredited. Minimum undergraduate GPA's are 3.5/4.0 for a Fellowship and 3.1/4.0 for an Associateship. For consideration, send ■ brief resume and transcripts before March 1, 1991 to: Dr. Roger Radcliff, Dept. of Electrical and Computer Engineering, 325 Stocker Center, Ohio University, Athens, OH 45701-2979.

The University of Minnesota, Duluth. The Department of Computer Engineering invites applications for two-tenure track faculty positions at the assistant or associate professor level, opening September 1, 1991. A Ph.D. in Electrical or Computer Engineering is required by the time of appointment for the assistant professor rank. In addition, appointment at the associate professor rank requires 6 years relevant teaching experience and distinction in scholarly activity. Duties will include undergraduate teaching and research. Preferred fields of interest include digital, analog, and solid-state electronics, VLSI design, and CAD, but applicants in other fields are also encouraged. Demonstrated evidence of effective teaching and communication skills appropriate to ■ faculty position is required. Completed applications must include ■ letter of application, a curriculum vita, and the names, addresses and telephone numbers of three professional references. The last date for receipt of applications is March 15, 1991. The University of Minnesota is an equal opportunity educator and employer and welcomes applications from women and minorities. Applications should be addressed to: Dr. Christopher R. Carroll, Chair, Computer Engineering Search Committee, 271 MWAH UMD, 10 University Drive, Duluth, MN 55812-2496.

University of Alabama in Huntsville (UAH) Department of Electrical and Computer Engineering. Five faculty positions -rank and specialty areas open. We seek U.S. citizens or permanent residents with excellent academic credentials holding the Ph.D. in electrical or computer engineering, or in cognate fields, with outstanding potential as teachers and researchers. Senior appointees should have a record of substantial research support and productivity. We are particularly interested in filling positions in computer engineering, opto-electronic devices and systems, communications, and electronics. The department, with 22 faculty members, currently enrolls 630 undergraduates and over 250 graduate students. Huntsville is a high technology community, with many federal and corporate opportunities for collaboration, support and consulting. A major new laboratory for optical science and engineering, currently under construction, will house optics-related research facilities, including the UAH Center for Applied Optics. Computer resources include a CRAY X-MP/24, a component of the Alabama Supercomputer Network. Salary and benefits are highly competitive while housing is very affordable. Huntsville is on the Tennessee River in the foothills of the Appalachian Mountains. Climate is temperate, and opportunities for recreational as well as cultural activities abound. Please send curriculum vitae with the names of three references to Professor Stephen T. Kowel, Chairman, Department of Electrical and Computer Engineering, University of Alabama in Huntsville, Huntsville, Alabama 35899. UAH is an Affirmative Action/Equal Opportunity Employer.

Graduate programs in Biomedical Engineering and Physics leading to the M.Sc. and Ph.D. degrees. Research assistantships available to highly qualified students. For further information, write to: Graduate Coordinator, Department of Applied Sciences in Medicine, University of Alberta, Edmonton, Alberta T6G 2G3.

Senior Professional Research Assistant. The Guided Wave Optics Laboratory at the University of Colorado, Boulder, seeks ■ Senior Professional Research Assistant to work in integrated optical and microwave device fabrication. He will be expected to assist doctoral students in their work and conduct his own research. He will work in the fabrication lab, coordinate lab operations and maintain equipment. At the beginning of employment, applicants must possess at least, an MS in Electrical Engineering with research emphasis on electro-optics or optical materials processing and one year of clean-room experience. Some previous fabrication work with various acousto-optical, optical and microwave materials including LiNbO3, LiTaO3, glass, GaAlAs, InGaAsP, ■ well as nonlinear optical polymers, is also essential. Candidates must be able to operate and maintain picosecond and femtosecond laser systems used for the research. Salary range is $31,000 to $33,000, based on expertise. Please send resume to: Prof. Alan R. Mickelson, E&CE Department, Campus Box 425, Boulder, CO 80309. The University of Colorado at Boulder has a strong institutional commitment to the principle of diversity in all areas. In that spirit, we are particularly interested in receiving applications from ■ broad spectrum of people, including women, members of ethnic minorities and disabled individuals.

Director. Center for Aircraft Systems Reliability. Candidates ■■ sought for the position of Director of the Center for Aircraft Systems Reliability (CASR) at Iowa State University. This center is aimed at the development of nondestructive evaluation (NDE) techniques for and their application to the commercial aviation fleet for the purpose of promoting safety and reliability in the fleet's operation. Candidates must be knowledgeable in the various aspects of current QNDE research and development, should be an expert in at least one of them, and should be familiar with the state of the technological art that is currently used in field inspections. It is expected that the successful candidate will be able to interact technically with both field test personnel as well as internal research people and will be interested in and capable of seeking and acquiring additional funding for the continued development of the program. This program is coupled closely to other interdisciplinary research centers at Iowa State University, particularly the ongoing Center for NDE. Salary is commensurate with experience. For qualified candidates, joint academic position can be arranged. To apply, send vita plus names and addresses of three references to: Personnel Office, 127 Spedding Hall, Iowa State University, Ames, IA 50011. Attention: Dr. Donald Thompson. "An Equal Opportunity/Affirmative Action Employer M/F/V/H."

Faculty Positions, Biomedical Engineering— The University of Southern California invites applications for tenure-track faculty positions in the ■■■■ of bioinstrumentation/bioelectronics, biosensors, cardiovascular, neural, and neuromuscular systems, medical imaging and signal processing, cellular bioengineering, or laser applications in medicine. Duties will include both teaching and research. Rank and salary will be commensurate with qualifications. Candidates must have ■ Ph.D. and/or M.D. degree and an established research record. Send curriculum vitae and the names of five references to: Vasilis Z. Marmarelis, Chairman, Department of Biomedical Engineering, University of Southern California, Los Angeles, CA 90089-1451. An Equal Opportunity/Affirmative Action Employer.

University of Nevada, Las Vegas, Faculty Positions. Two tenure track positions are available at the University of Nevada, Las Vegas. One position requires ■ minimum of ten years academic/ industrial experience since receiving the Ph.D. At least six of these should have been at ■ Ph.D. granting institution. Appointment will be at the appropriate rank. An established record of scholarly research and effective teaching is required. Preferred areas include digital signal processing, computer engineering and power electronics/energy conversion. The second position is expected to be filled at the assistant professor level. Preference will be given to candidates in signal processing or communication theory. The major qualifications are the ability and desire to excel at teaching and to initiate a productive research program. UNLV is a dynamic and growing institution. The Howard R. Hughes College of Engineering located in ■ 101,000 square foot complex, is the newest college on campus. The Dept. of Electrical and Computer Engineering has an ABET accredited undergraduate program, has approximately 200 undergraduates and 20 graduate students. The M.S. degree is offered in the major specialization areas within electrical and computer engineering. A Ph.D. program is in the planning stage. Computational facilities of the department include VAX, Micro VAX, Sun SPARC, and NEXT workstations, sharing about 6 Gbytes of file service and interconnected by the departmental ethernet. A new super computer (CRAY YMP-2) is available to faculty and graduate students for ongoing research. A let-

ter outlining your goals and expectations, along with a resume and names of three references should be sent to Dr. William L. Brogan, Chair, Dept. of Electrical and Computer Engineering, University of Nevada, Las Vegas, 4505 Maryland Parkway, Las Vegas, Nevada 89154. Applications will be accepted until 3/15/91 or until the position is filled. The appointment is expected to become effective in the fall semester, 1991. UNLV is an EE/AA employer and encourages women and minorities to apply.

University of Colorado at Denver. The Department of Electrical Engineering and Computer Science invites applications for several tenure track positions. Applicants must have ■ Ph.D., the ability to teach effectively at both the undergraduate and graduate levels, and to conduct independent research. Particular need exists for faculty with research interests in controls and hardware-software interfaces but other applicants will be considered. The University of Colorado at Denver particularly invites and encourages applications from women and minorities. Send resume and names of three references to: Electrical Engineering Faculty Search Committee, Department of Electrical Engineering and Computer Science, University of Colorado at Denver, Campus Box 110, P.O. Box 173364, Denver, CO 80217-3364. Review of applications will begin on February 1, 1991 and continue until all positions are filled.

The University of Toledo. The Electrical Engineering Department invites applications for ■ tenure track position in VLSI Systems beginning September 1991. A Ph.D. in electrical engineering or a related area required. Responsibilities include undergradute and graduate teaching and research. Candidates with a background and an interest in VLSI or IC CAD tool development are especially encouraged to apply. State University with 24,000+ students including 2200+ students in B.S., M.S., and Ph.D. engineering programs. Rank and salary are open. Send applications with resume containing names and addresses of three (3) references by February 28, 1991 to Dr. Kai Fong Lee, Chairman of Electrical Engineering Department, The University of Toledo, Toledo, OH 43606-3390. Non-US citizens must indicate their immigration status. The University of Toledo is an Equal Opportunity/Affirmative Action Employer.

Head of Electrical Engineering and Endowed Chairs in Micro-electronics and in Telecommunications. The Erik Jonsson School of Engineering and Computer Science at The University of Texas at Dallas is seeking experienced researchers to lead our Electrical Engineering program; to lead programs of experimental research in microelectronic devices and fabrication; and to lead programs of research in communications, signal processing and digital systems. Research areas in Microelectronics include advanced compound and elemental semiconductor devices, optoelectronics, and nanoelectronics using quantum-effect devices. Research areas in Telecommunications include digital communication systems, optical communication systems, information theory and coding, digital signal processing, VLSI design, computer architectures and high performance computing. The University of Texas at Dallas is located in ■ center of microelectronics and telecommunications. The Erik Jonsson School serves the needs of ■ large technologically sophisticated metropolitan area where opportunities exist for interaction with industry. The Engineering and Computer Science Building has 150,000 sq. ft. of laboratory and office space including 5,000 sq. ft. of research cleanroom, 4,600 sq. ft. of research laboratories for electronic device characterization and optics; and 10,000 sq. ft. of research laboratories for telecommunications and computers. Appropriate start-up funding is available. Interested applicants should send ■ resume to: Dr. B.E. Cherrington, Dean, Erik Jonsson School of Engineering and Computer Science, The University of Texas at Dallas, P.O. Box 830688, Richardson, TX 75083-0688. The University of Texas at Dallas is an equal opportunity/ affirmative action university.

Professor and Head, Manufacturing Systems, The Erik Jonsson School of Engineering and Computer Science at The University of Texas at Dallas is seeking ■■ experienced senior researcher to lead our Manufacturing Systems Program. The program emphasizes the design of computer supported/controlled systems for engineering and manufacturing. Current research areas include machine vision systems, CAD, robotics and expert systems. Candidates must have a Ph.D. or equivalent in engineering or related discipline, and ■ demonstrated record of scholarly productivity and the ability to attract research sponsorship. The University of Texas at Dallas is located in ■ center of electronics manufacturing. The Erik Jonsson School serves the needs of ■ large technologically sophisticated metropolitan area where opportunities exist for interaction with industry. The Engineering and Computer Science Building has 150,000 sq. ft. of laboratory and office space of which 7,500 sq. ft. of laboratory space is devoted to research in manufacturing systems. Appropriate start-up funding is available. Interested applicants should send ■ resume to: Dr. B.E. Cherrington, Dean, Erik Jonsson School of Engineering and Computer Science, The University of Texas at Dallas, P.O. Box 830688, Richardson, TX 75083-0688. The University of Texas at Dallas is an equal opportunity/affirmative action university.

University of South Carolina, Department of Electrical and Computer Engineering, invites applications for tenure-track faculty positions. Particular ■■■■ of interest include quantum and physical electronics, computer architecture and computer vision. Persons of high caliber in other areas will also be considered. Appointment will be at the Assistant or Associate Professor level with a competitive salary and rank commensurate with qualifications. Tenured appointments at the level of Professor ■■ also possible for uniquely qualified individuals. The USC, as the flagship university of the state, seeks candidates having ■ strong commitment to excellence in both education and research. Candidates for Associate Professor are expected to have significant research records. Candidates for Assistant Professor areexpected to show strong research potential. Positions may be filled ■■ early as January, 1991 but will remain open until suitable candidates are found. Applicants should send resumes, including names of at least three references, to Professor Etan Bourkoff, Chair, Department of Electrical and Computer Engineering, Swearingen Engineering Center, University of South Carolina, Columbia, SC 29208. The University of South Carolina is an equal opportunity/affirmative action employer.

Grand Valley State University. Director, School of Engineering. Opportunity to shape a unique engineering educational program. Dynamic, innovative individual sought to lead a new ABET accredited engineering program in ■ period of growth and development. Applicant should have academic administrative experience and ■ doctorate in an engineering discipline. Industry experience is preferred. Should have interest in laboratory based teaching and be able to administer a program with firm ties to the industrial community of west Michigan. Grand Valley offers a general engineering degree with mandatory industry experience. Future expansion to mechanical, electrical and manufacturing designated degrees anticipated. Grand Valley State University is the fastest growing state supported institution of higher education in the state of Michigan. It is located in Grand Rapids near Lake Michigan with many cultural and recreational opportunities. Send ■ letter of interest, vita and list of references to: Dr. P. Douglas Kindschi, Dean of Science and Mathematics, Grand Valley State University, Allendale, MI 49401. Applications will be accepted until position is filled. Starting date will be July 1991. AA/EOE.

Tulane University invites applications and nominations for the position of Dean of the School of Engineering. Established in 1884, the School of Engineering offers baccalaureate, master and doctoral degrees i Biomedical, Chemical, Civil, Electrical, Mechanical Engineering, and Computer Science, accredited by national accrediting agencies. Reporting directly to the Provost, the Dean serves as the academic and educational leader and chief administrator of the School of Engineering. The Dean is responsible for administering all facets of the College, providing leadership to the faculty, providing guidance in curriculum development, stimulating faculty in instruction and research, and articulating plans for future developments. The Dean is responsible for administering relations between the University and the industrial and business community. Criteria for the appointment include: 1) An earned doctorate in engineering or ■ science-related field, and a record of teaching experience to merit the rank of a tenured Professor in one of the departments in the School of Engineering. 2) Demonstrated ability to work successfully in an institution that serves an ethnically and culturally diverse population. 3) Distinguished record in teaching, scholarship, research, and professional activity. 4) Experience in administrative coordination and in the acquisition of external funding. 5) Ability to promote effective working relationships with faculty members, staff, and students. We expect to make an appointment effective 1 July 1991. Therefore, w■ invite nominations immediately. Nominations and applications will be accepted until the position is filled. We particularly seek applications from women and members of minority groups who would qualify for this position. Applications should include ■ curriculum vitae, ■ letter of interest, and the names, addresses, and telephone numbers of three professional references. Applications should be sent to: Chair, Engineering Dean's Search Committee, Tulane University, Office of the Provost, 327 Gibson Hall, New Orleans, LA 70118. Tulane University is ■■ Equal Opportunity, Affirmative Action Employer committed to cultural diversity.

The Ohio State University invites applications and nominations for the position of Dean of the College of Engineering. The Dean will lead a distinguished 260-person faculty, serving 4,500 undergraduates and 1,400 graduate students in 16 academic units. The Dean will administer ■ total budget of $90,000,000, including the sixth largest engineering college research budget in the United States, and will have the support of 30,500 College of Engineering alumni. The candidate should be a recognized leader in engineering administration, research and teaching. The Dean will be ■ key member of the university leadership and will be expected to contribute to the broad academic and cultural missions of the entire university. The position will be available July 1, 1991. The Ohio State University is an equal opportunity/affirmative action employer, and the candidate must be committed to these principles. Applications will be accepted and reviewed until the position is filled. Send applications and nominations, including curriculum vitae and the names of three references to: Professor Leon Peters, Jr., Chair of Search Committee for the Dean of the College of Engineering, Department of Electrical Engineering, The Ohio State University, 2015 Neil Avenue, Columbus, OH 43210.

University of Arizona. The University of Arizona Electrical and Computer Engineering Department invites applications for tenure track faculty appointments for the 1991-92 academic year. Preference will be given to applicants at the Assistant Professor level, but exceptional candidates at higher levels may also be considered. In addition to ■n earned doctorate and a commitment to effective teaching at both the undergraduate and graduate level, it is essential that candidates have outstanding research achievement and/or potential and the commitment and ability to establish an externally sponsored research program. Technical areas of particular interest for 1991-92 recruiting are computer engineering including AI/robotics, signal and image processing including pattern recognition/ neural networks, telecommunications, and microelectronics including analog circuits. Applicants should send a resume, a statement of teaching and research interests, and a list of three references to: Prof. K.F. Galloway, Department Head, Electrical and Computer Engineering Department, University of Arizona, Tucson, AZ 85721. Applications will be reviewed starting January 15, 1991 and will be received until open positions are filled. The University of Arizona is and Equal Opportunity/Affirmative Action Employer and specifically invites women and minorities to apply.

Harvey Mudd College, Electrical Engineering. Applications are invited for a tenure track position in the Engineering Department, beginning Fall Semester 1991. Appointment at the Assitant Professor level is anticipated. The position requires demonstrated capabilities in two or more of the following areas: analog/digital

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PRE-EMPLOYMENT PATENT AGREEMENTS

Employed Engineers: Who Owns Their Inventions? was published by IEEE United States Activities as a guide for leaders of professional activities groups. This booklet explains a number of pre-employment patent agreements and what they mean to the employed inventor. Detailed guidance on the assignment of rights, forms of reward, confidentiality of employer information, disclosure of prior inventions, and a sample agreement are included.

Copies are on sale to members through the IEEE Service Center, Box 1331, 445 Hoes Lane, Piscataway, N.J. 08855-1331; 201-981-1393 or 800-678-IEEE. Ask for Catalog No. UH0147-9. Price is US $5.00 for members and US $6.50 for nonmembers.

Or, for additional information, CIRCLE #95 on the Reader Service Card.

AMERICAN ASSOCIATION OF ENGINEERING SOCIETIES GOVERNMENT AFFAIRS CONFERENCE IEEE COMPETITIVENESS WORKSHOP March 6, 1991

IEEE's Technology Policy Conference Committee, a joint committee of IEEE's United States Activities and Technical Activities boards, is organizing a workshop on U.S. competitiveness at the 1991 Engineering Societies Government Affairs Conference. Dr. Oscar Garcia chairs the IEEE's joint committee.

The conference will take place on March 6, 1991, at the Madison Hotel in Washington, D.C. Sponsored by the American Association of Engineering Societies, the conference will introduce the professional engineering community to important issues facing the incoming 102nd Congress.

Dr. Robert White, under secretary for technology in the Department of Commerce and an IEEE Fellow, will deliver a major presentation during the morning plenary session on the Federal government's role in promoting U.S. competitiveness. Dr. Robert Frosch, vice president for research of General Motors Corp. and an IEEE Fellow, will moderate the IEEE's afternoon Competitiveness Workshop. This session will include discussion by two panels of prominent industry and government spokesmen on actions that must be taken by both the private and the public sectors to promote U.S. competitiveness.

The audience will include engineering society leaders, Congressional and Executive Office staff, members of the media, and members of the engineering, science, and technology communities.

For more information and for registration materials, CIRCLE #94 on the Reader Service Card.

1991 SPRING CATALOG IEEE SOFTWARE ENGINEERING SEMINARS Chicago, March 1991 San Francisco, September/October 1991

- Software Reviews and Audits
- Software Quality Assurance
- Software Testing
- Software Project Management
- Software Verification and Validation
- Software Requirements Specifications
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Careers Conference Calls for Papers

IEEE-USA's Seventh Biennial Careers Conference, whose theme is "Change and Competitiveness and Careers," will take place in October 1991 in Denver, Colo.

Organized by IEEE-USA's Career Maintenance and Development Committee, under the direction of conference chairman Marlin P. Ristenbatt, the Biennial Careers Conference provides a national forum for all aspects of technical careers. Its goals are to contribute to U.S. competitiveness and to improve individual careers in a rapidly changing world.

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(Continued overleaf)

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papers on any aspect of engineering careers and the organization and government practices affecting those careers, based on data, experience, or an expert opinion. Career researchers, executives from industry and government, human resource managers, career and management consultants, organizational development specialists, and individual engineers and scientists are potential contributors.

Six copies of 500-word abstracts must be received in the IEEE-USA Office in Washington, D.C., by Feb. 1, 1991. Notifications of acceptance will be sent by April 1, and camera-ready papers are due by Aug. 1. Relevant conference topics for papers include:

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electronics, VLSI, and materials. Responsibilities will include teaching in a unified engineering curriculum, developing courses, and supervising industrially sponsored projects in the Engineering Clinic. Continuing professional growth and development through research or consulting is expected; excellent opportunities exist in the local area. A doctorate is required for the position. Industrial experience is desirable. Reply to: Electrical Engineering Search, Attention: John I. Molinder, Chairman of Engineering, Harvey Mudd College, Claremont, CA 91711. Send application by March 1, 1991. Harvey Mudd College is an equal opportunity/affirmative action employer.

The Department of Electrical Engineering invites applications and nominations for 3 tenure track positions in the area of Control Theory at the rank of Assistant or Associate Professor. Qualifications should include an outstanding academic record, significant achievements in original research, sincere interest in teaching, and ■ Doctorate in Electrical Engineering or related area. Application deadline is February 28, 1991. Please send a resume and the names and addresses of at least three professional references to: Professor T.E. Bullock, Department of Electrical Engineering, University of Florida, Gainesville, FL 32611. Citizens of foreign countries please indicate US Visa status. The University of Florida is an Affirmative Action Employer. Women and minorities are encouraged to apply. According to Florida law, applications and meetings regarding applications are open to the public on request.

Faculty Position Available in Control Systems—University of Illinois at Urbana-Champaign. The Department of Mechanical and Industrial Engineering (M&IE) of the University of Illinois at Urbana-Champaign seeks applications and nominations for a tenure-track or tenured faculty position in the control systems area at the level of Assistant Professor, Associate Professor, or Professor. Candidates should have ■ strong background in control theory. Outstanding candidates in all areas of control systems will receive serious consideration; applications are particularly encourage from person with an interest in the theory of control of distributed parameter systems and its applications to combustion, fluid mechanics, heat transfer, propulsion, solid mechanics, structures, or other relevant areas. Opportunities exist for interaction with faculty in these areas, as well as with control systems faculty in M&IE and other units of the College of Engineering. The individual must have a PhD degree and must be committed to teaching at both the undergraduate and graduate levels ■ well as to attracting and conducting sponsored research. Salary is commensurate with education and experience. In order to ensure full consideration, applications must be received by March 15, 1991. Proposed starting dates are May 21, 1991 or August 21, 1991. Send up-to-date biography with names of four references to: Professor A. L. Addy, Head, Department of Mechanical and Industrial Engineering, University of Illinois at Urbana-Champaign, 138 Mechanical Engineering Building, 1206 West Green Street, Urbana, IL 61801; (217) 333-1126. The University of Illinois at Urbana-Champaign is an affirmative action/ equal opportunity employer.

Executive Director, Washington Technology Centers. The Washington Technology Centers (WTC) is seeking candidates and nominees for the position of Executive Director. The WTC is Washington State's premier university-industry collaborative research program, established in 1983 by the Washington State Legislature and designed to foster private and federal investment for commercially promising research and technology development. WTC research activities are located primarily on the University of Washington and Washington State University campuses. As a leader in commercially promising research and technology development in the areas of advanced materials, compound semi-conductors, computers and software, manufacturing systems, microsensors, and medical and plant biotechnology, the WTC creates technologies for industry application with ■ focus on Washington State. The Executive Director has overall management and administrative responsibility for seven distinct research areas/programs, with projected biennial activity of $27.2 million (state, federal, foundations and industry combined) and an eleven-person headquarters staff. Functions and responsibilities: chief WTC representative to government, industry and university leadership; responsible for long-range planning, major facilities planning and acquisition; develops and implements WTC policies and procedures; and oversees intellectual property agreements. Qualifications: Broad knowledge of science and engineering, Ph.D. in an appropriate field (only exceptional relevant experience will substitute for ■ Ph.D.). Position is available immediately. Interviews will begin early in 1991 and will continue until the position is filled. Send nominations or ■ resume, names and addresses of four or more references, and ■ letter of interest highlighting the special skills that you could contribute to the development and success of the WTC to: Dean G. Ross Heath, Chair, Search Committee for the WTC Executive Director, College of Ocean and Fishery Sciences, HN-15, University of Washington, Seattle, WA 98195. The University of Washington is an equal opportunity/ affirmative action institution and encourages women and minorities to apply.

Thomas J. Watson School of Engineering, Applied Science ■ Technology. The Department of Electrical Engineering of the State University of New York at Binghamton invites applications for ■ tenure-track faculty position in the area of digital electronics. Successful applicants will be expected to teach appropriate courses, develop active research programs, and supervise MSEE and Ph.D. research. A Ph.D. in electrical engineering or a closely related field is required. Rank and salary will be commensurate with experience and qualifications. Applications including a full resume, three references (with phone numbers) and recent publications, should be sent to: Dr. J.E. Morris, Chairman, Department of Electrical Engineering, Watson School, SUNY-Binghamton, NY 13902-6000. FAX: (607) 777-4822. The State University of New York at Binghamton is strongly committed to affirmative action. We offer access to services and recruit students and employees without regard to race, color, sex, religion, age, disability, marital status, sexual orientation or national origin.

University of Missouri—Columbia—Research Assistant Professor. The College of Engineering is seeking a highly motivated and talented individual with experimental research skills in the synthesis and characterization of photovoltaic materials. A PhD or equivalent experience is required. We offer a challenging three year research project on advanced materials for nuclear energy conversion (working with four senior faculty and four graduate students), ■ congenial and stimulating atmosphere, a competitive salary, and excellent benefits. This position will begin January 1991. Interested individuals are invited to send their resumes to Professor Mark A. Prelas, 323 Electrical Engineering Building, University of Missouri-Columbia, Columbia, ■O 65211.

Electrical Engineering Technology at Purdue University anticipates tenure-track positions at West Lafayette, Columbus, and Kokomo, Indiana, commencing August 12, 1991. Minimum requirements are: master's degree in Electrical Engineering, Engineering Technology, or closely related field; 3 years of recent relevant industrial experience; commitment to undergraduate teaching; and expertise in at least 2 specialty areas. Candidates from industry and strong 2-year and 4-year engineering technology programs are sought. Faculty are involved in teaching, curriculum development, student advising, and various committees. They pursue scholarly activity by publishing and participating in professional societies. Closing date is March 18, 1991, or until filled. Send a detailed resume and mention the location desired to: Prof. W.F. Reeve, Faculty Search Committee, Electrical Engineering Technology, Knoy Hall, Purdue University, West Lafayette, IN 47907. Purdue is an equal opportunity/ affirmative action employer.

Faculty Positions in the Electrical Engineering Department at The University of North Carolina at Charlotte, Charlotte, NC 28223. The Electrical Engineering Department at the University of North Carolina at Charlotte invites applications for two tenure-track positions at the Assistant, Associate, or Full Professor level. Areas of interest include signal and image processing/ communications (including optical signal processing and telecommunications), and microelectronics (including optoelectronics, process technology, system integration, nonometric devices, and analog/digital VLSI design). Positions begin Fall of 1991. The University of North Carolina at Charlotte is one of the largest institutions of the UNC system. It has over 14,000 students, including 2,125 graduate students in the six colleges. The department is one of five in the College of Engineering and currently enrolls 350 students, of which 50 are graduate students and Postdoctoral Research Associates. Computer facilities include micros, minis, workstations and free access to Cray YMP supercomputer. The laboratory facilities include a class 100 clean room with complete integrated circuit and microstructure fabrication capabilities, laboratories for measuring the electrical properties of the insulator-semiconductor surface, computerized IC test facilities, laser electro-optic laboratory, dry processing laboratory for VLSI fabrication, and MBE laboratory for quantum well superlattice and optoelectronic materials. As ■ participating institution of MCNC (Microelectronics Center of North Carolina), the faculty have access to the MCNC facilities with capabilities of submicron IC design, fabrication, test, and semiconductor materials analysis. Charlotte is the largest city in the Carolinas and offers good schools and attractive housing. The 100,000 sq. ft. engineering building and ■ 75,000 sq. ft. applied research building are located adjacent to the 2,800 acre University Research Park. Various forms of career development support are available. Applicants should have ■ Ph.D. degree or equivalent and have commitment to teaching and pursuing research. Industrial and research experience is desirable. Rank and salary commensurate with experience. Applications will be accepted until March 1, 1991. Initial screening begins February 1, 1991. Applications, including a resume and four references, should be sent to: Rafic Makki, Chairman, Search Committee, Electrical Engineering Department, UNC-Charlotte, Charlotte, NC 28223. UNC-Charlotte is an equal opportunity affirmative action employer, and complies fully with the immigration Reform and Control Act of 1986.

Southern University, Chair, Electrical Engineering Department. Nominations and applications are invited for the position of Chairman of the Electrical Engineering Department at Southern University at Baton Rouge, Louisiana. The successful candidate must have an earned doctorate, and a demonstrated record of excellence in teaching, research, and service suitable for appointment at the rank of associate or full professor. The selected candidate must have a vision of the future directions for electrical engineering and have the leadership and managerial skills to promote and implement this vision. Professional registration and industrial experience are desirable. Southern University is a historically black university located in Baton Rouge, Louisiana. The Electrical Engineering Department has twelve full time faculty positions and offers the B.S. degree in Electrical Engineering. Current enrollment in Electrical Engineering is about 500 students. The successful candidate must have ■ strong commitment to further developing research endeavors in the department. Nomination and applicants should send ■ resume and the names and addresses of five references to: Dr. Thomas L. Henderson, Search Committee Chairperson, College of Engineering, Southern University, Baton Rouge, Louisiana 70813-9552, no later than February 15, 1991. Minorities and women are strongly encouraged to apply. The position is available in June 1991. Salary is competitive and commensurate with qualifications. Southern University is an affirmative action and equal opportunity employer.

University of North Carolina at Charlotte, Department of Computer Science. Two tenure-track positions are available in all areas at Assistant, Associate, or Full Professor level in Computer Science/Computer Engineering. The salary is competitive. A Ph.D. in CS/CE is preferred. A Ph.D. in ■ area related to CS/CE will be considered. Applications will be accepted until the positions are filled. The Department of Computer Science is housed in the College of Engineering and offers both undergraduate and graduate degrees in computer science. Active research areas in the department include artificial intelligence, computer architecture, computer vision, database systems, data communication, distributed systems, theoretical CS, and VLSI design. On-campus Ph.D. level research and study are available through cooperation with other participating institutions of the Microelectonics Center of N.C. (MCNC). A wide variety of excellent computing facilities includ-

ing IBM, VAX, Xerox, Sun, and others are available to support educational and research activities. Also, as a participant in MCNC, UNCC has access to state-of-the-art computing (e.g., Cray Supercomputer, VLSI design, and fabrication facilities). UNCC is a dynamic, growing university. Charlotte is the largest city in the Carolinas with excellent housing, good schools, a modern international airport, and mild climate. Curriculum Vita, transcript, and four letters of reference should be sent to Chairperson, Faculty Search Committee, Department of Computer Science, The University of North Carolina at Charlotte, Charlotte, NC 28223. UNCC is an EOE/AA Employer.

Graduate Associateships in Avionics Engineering or power electronics/industrial control. Associateships are available for M.S. or Ph.D. students in Electrical Engineering specializing in these areas. Students will be expected to perform research on funded or related projects within the Avionics Engineering Center, a research branch of the Department of Electrical and Computer Engineering, on projects related to power electronics/industrial controls, or on manufacturing related projects supported by a grant from Cooper Industries. Applicants must possess a B.S.E.E. and a minimum undergraduate GPA of 3.3/4.0. The stipend is $12,000 for 12 months for M.S. students and $15,000 for 12 months for Ph.D. students, plus tuition waiver. Send a brief resume and transcripts before March 1, 1991 to: Dr. Roger Radcliff, Dept. of Electrical and Computer Engineering, 325 Stocker Center, Ohio University, Athens, OH 45701-2979.

University of Denver, Department of Engineering. Applications are being accepted for two Electrical Engineering tenure-track positions (one Associate and one Assistant Professor). The candidates must be willing to teach, perform, research, and help build new graduate engineering programs. All candidates should possess an earned doctorate with an excellent record of teaching, scholarship, and service. Individuals must have a background in either Digital Systems, or Microelectronics, and be able to teach in at least three of the following areas: Digital Systems, Microelectronics, Robotics/Controls, and Communications. The Associate Professor position requires a minimum of four years experience in U.S. industry or government. U.S. citizenship or permanent residence status is required. Applicants should submit a resume, a letter of recommendation and three other references to: Dr. Roger Salters, Department of Engineering, University Park, Denver, CO 80208-0177. Salaries and benefits are competitive. The University of Denver (Colorado Seminary) is a private, mid-sized, research university and the oldest in Colorado. Its engineering programs were recently reestablished and are ABET accredited. University of Denver is committed to enhancing the diversity of its staff and faculty and encourages applications particularly from women, minorities and the disabled.

Manager Power Plant, University of Iowa Power Plant. Individual will be responsible for managing the operation and maintenance of the University steam and electrical generation facilities, including the campus steam distribution system. The University of Iowa has a 21 MW coal fired power plant including a fluidized bed boiler. Minimum qualifications include a Bachelor's degree in Engineering or an equivalent combination of education and experience which provide a comparable level of knowledge. Individual must possess at least 5 years experience in power plant management or supervision with at least 2 years in a coal fired plant. The University of Iowa offers an excellent benefits package in addition to a competitive salary commensurate with experience. Interested candidates should forward a letter of application, resume and salary history to: John Schenk, Associate Director for Utilities, University of Iowa, Physical Plant, Department, Iowa City, IA 52242. The screening process will begin on January 15, 1991. The University of Iowa is an Equal Opportunity/Affirmative Action Employer.

Faculty Search—Electrical & Systems Engineering. The Electrical and Systems Engineering Department at the University of Connecticut invites qualified candidates to apply for an anticipated tenure-track Assistant Professor position. A doctoral degree in Electrical Engineering or Applied Sciences with experience in any one or a combination of the following areas is required: optoelectronic devices, integrated optics, fiber optic sensors, electrooptic systems, photonic switching and ultrashort laser pulses, and telecommunications. Required duties include teaching at the undergraduate and graduate levels, obtaining external funding and performing research in the candidate's area of expertise, and supervising graduate student research. Hands-on experience in device fabrication with publications in major professional journals will be given special consideration. Starting salary will be commensurate with candidates' qualifications. The University of Connecticut is the largest state institution in Connecticut located in a beautiful rural area within easy reach of Boston and New York City. Please mail application and resume to: Chairman, Faculty Search Committe, University of Connecticut, Electrical & Systems Engineering Department, U-157, 260 Glenbrook Road, Storrs, CT 06269-3157. AA/EOE. (Search #1A168).

The Bradley Department of Electrical Engineering of Virginia Polytechnic Institute and State University invites applications for several tenure track faculty positions. Greatest needs are in the areas of electronic materials (a joint position with Materials Engineering Department) and communications with emphasis on high frequency electronics. Consideration will be given to applicants in all areas at the Assistant and Associate Professor level. Applicants must have an earned doctorate, be interested in undergraduate and graduate teaching, and be willing to secure research sponsorship. Virginia Tech is Virginia's land grant university offering degrees through the Ph.D. Send complete resume with references and employment/citizenship status to: Professor W.L. Stutzman, Chairman, Personnel Committee, Bradley Department of Electrical Engineering, Virginia Tech, Blacksburg, VA 24061-0111. Applications will be accepted until April 15, 1991, or until suitable candidates are selected. Virginia Tech is an Equal Opportunity/Affirmative Action Employer.

Government/Industry
Positions Open

Research Engineer for firm in NE Ohio. To conduct research into new transmission media for application in microwave and millimeter wave integrated circuits. This will involve identifying promising transmission media discontinuities, developing detailed analytical models for typical discontinuities, fabricating and experimentally evaluating the discontinuities and comparing analytical and experimental results. Additionally, the research will involve incorporating solid state devices, such as field effort transistors and beam lead diodes, into full circuits. Also contemplated is research on photonics, in particular the optical control of microwave devices. Must have Ph.D. in Electrical Engineering and academic program must have included one graduate level course each in: Microwave Circuits and Antennas, Microwave Active Devices, and Design of Array Antennas. Must be conversant with electromagnetic wave theory and millimeter wave transmission lines (e.g., slot line, coplanar waveguide, and fin line); and optical control of microwave solid state devices, as evidenced by employer testimonials or publications. Must have 2 years of experience as research assistant and experience must have been in research on microwaves. 8am-4:30pm, 40 hrs/wk, $54,000/yr. Must have proof of legal authority to work permanently in U.S. Send resume and course transcript in duplicate (no calls) to G. Maugans, JO# 1255623, Ohio Bureau of Employment Services, P.O. Box 1618, Columbus, Ohio 43216

Systems Engineer with Masters in Electrical Engineering. 2 years experience in job offered or 2 years experience as systems analyst. 40 hours/week. $50K/year. Utilize knowledge of electronics and data processing principles and equipment to interface A.S.K. manufacturing systems and AVP tax systems with DEC/VAX and HP computer and operating system that will provide system capabilities required for projects or workloads on existing LAN systems. Apply at the Texas Employment Commission, Houston, Texas, or send resume to the Texas Employment Commission, TEC Building, Austin, Texas 78778, JO#5515183. Ad Paid by An Equal Employment Opportunity Employer.

Research Openings: Bharat Electronics, a premier professional electronics industry in India, invites applications for its central research laboratory at Bangalore & Delhi Centres. Bangalore Centre has 3 labs: information systems, software engineering, and CAD/CAE. The Delhi Centre, which is to be established soon, will have another 3 labs: systems engineering, microwave engineering and advanced computer applications. CRL wishes to recruit principal scientists, members (senior research staff) and members (research staff). Applications including curriculum vitae, list of publications, references and technical interests should reach the following address by 31 MAR 1991. Citizenship is a must. Asst. Personnel Officer, Bharat Electronics Limited, Central Research Laboratory, 25, M.G. Road, Bangalore 560 001 India.

Associate Electronics Design Engineer. Conducts development activities concerned with the design, manufacture, and testing of electronic products, and in development of applications of products to medical uses. Designs electrical circuits and integrated systems, using electronic theory, principles of electrical circuits, electrical testing procedures, engineering mathematics, physics, and related knowledge. Assembles experimental circuitry (breadboard) or complete prototype model according to design. Sets up standard test apparatus or devises test equipment and circuitry, and conducts functional, operational, environmental, and life tests to evaluate performance and reliability of prototype or production models. Analyses and interprets test data. On large projects may work under the direction of a Senior Design Engineer. Requires B.S. in Electrical Engineering. Requires 2 years experience in the job offered or 2 years analog/ digital circuit experience, including use of the following test equipment: oscilloscopes, digital voltmeters, dynamic signal processors, signal generators, final test and repair of electronic medical equipment. $14.00/hr, 40 hrs/wk, M-F 8:00am-5:00pm. Position located in Seattle, WA area. Must have legal authority to work permanently in the U.S. Send resume by January 31, 1991 to: Employment Security Department, KG-11, ES Division, Attn: Job # 237984, Olympia, WA 98504.

CAD Engineering Senior Member I. Design testable/fault tolerant Built-in Self-Test (BIST) controllers for Programmable Logic Arrays (PLAs) to achieve high quality products. Support timing analysis methodology/tools for various designs to help in detection of timing problems. Develop behavioral models for validation of VLSI chip/system specifications and automated logic synthesis. Minimum requirements: B.S. or equivalent in Electrical Engineering; Graduate course work in VLSI Design, Fault Detection and Testing, Fault Tolerant Computing and Semiconductor Device Physics; 6 months experience or training in the design of BIST controllers for PLAs; 2 years experience in the design or maintenance of mainframe or supermini computer hardware systems; one year experience, which can be concurrent experience, in the design of software. $38,000/Yr. 40 hour week. For consideration, send resume to Colorado Department of Labor and Employment, 600 Grant Street, Suite 900, Denver, CO 80203-3528. Refer to order #CO3194026.

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Technical Support Specialist for SE OH employer. Duties: 1) checking out circuit board & assembled products, using advanced electronics test equipment including digital logic analyzer & EPROM programmer. 2) troubleshooting & repair, & responding to customers' technical questions. 3) defining & installing hardware upgrades to meet changing market requirements for the product. 4) use of IBM-PC & Apple computers to revise & extend existing programs written in assembly language. Must have BSEE with at least two courses in digital systems design. No exp. required in above duties but applicants will qualify with 1 yr. electronics engineering; exp. to include practicing advanced PC-DOS operations including 3 mos. with assembly level programming on PC at both DOS & BIOS level. MSEE with thesis work in digital systems design acceptable in lieu of BSEE & 1 yr. exp. 40/ hrs/ wk, 9am-5:30pm, $14.00/ hr. Must have proof of legal authority to work permanently in U.S. Send resume in duplicate (NO CALLS) to J. Davies, JO#1221614, Ohio Bureau of Employment Services, PO Box 1618, Columbus, OH 43216.

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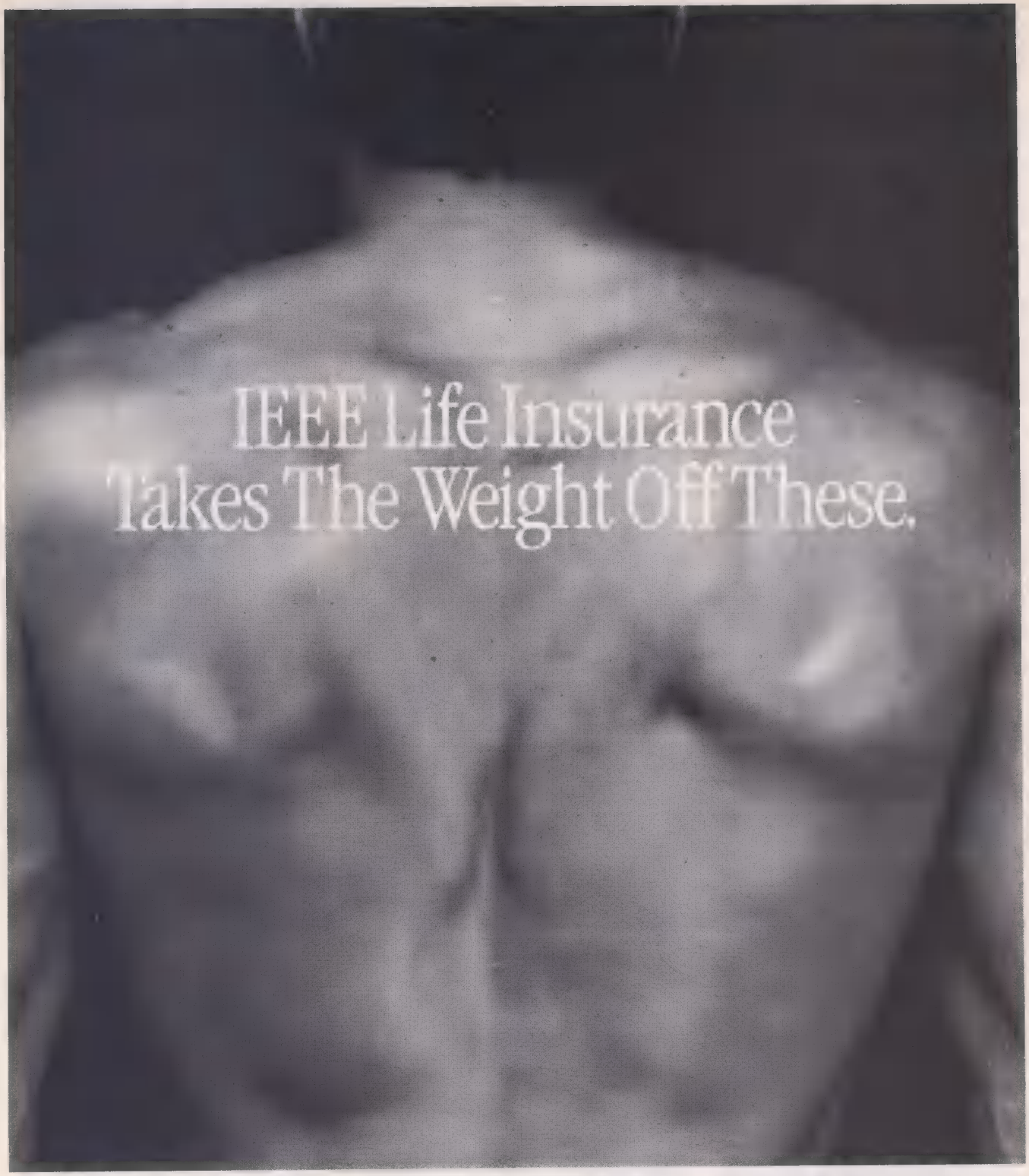
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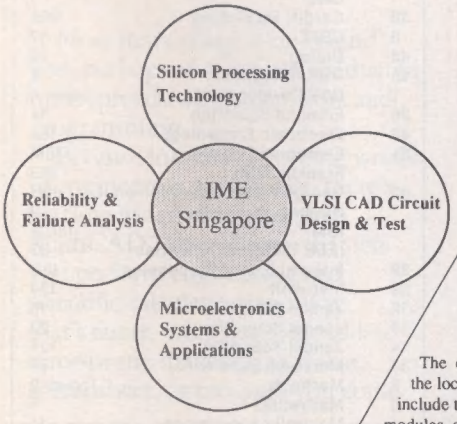
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This group will provide services in failure mode analysis and modelling of failed components from field returns and factory tests, in reverse engineering of components, in developing component screen procedures and in yield improvement and reliability consulting. The appointee will assume a role of quality champion.

VLSI CAD, Circuit Design and Test

Concepts and architectures developed at the Institute will be captured by this group through VLSI circuit design and test and through the use of CAD, to which the group's main role will be tool integration. Special emphasis will be placed on the design and test of mixed digital and analog ICs.

Microelectronic Systems and Applications

This group has the responsibility of identifying and realizing, prototypes of board-level products which have high potential in the market place. The appointee has the responsibility of establishing skills in product definition, system partitioning and system integration and test.

An attractive and comprehensive remuneration package which includes settling-in allowance, subsidised housing, educational allowance, passage assistance and medical benefits will be offered.

Qualified applicants should send a two-page resume with a brief cover letter, in confidence, to :

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Please apply before April 1, 1991. Applications will be processed as soon as they are received.

IEEE plans return to balanced budgets

IEEE President Eric Sumner told THE INSTITUTE that "there is no fundamental reason why IEEE cannot return promptly to balanced budgets." The 1991 general-fund operating budget draws on IEEE reserves as was the case the two previous years.

Sumner's plan includes developing draft budgets several years in advance, beginning with the 1992 budget, and revising the revenue estimates for each. A key goal is to have IEEE entities reimburse the general fund for corporate services performed at cost, and to increase income to the fund from such entity activities as publication sales. He also said that general-fund support should come from new income rather than existing streams, but that difficult choices will still have to be made [THE INSTITUTE, January, p. 8].

France's nuclear power success

Nuclear plants produce three-quarters of France's annual output of 387 terawatt-hours (1400 terajoules), and Electricité de France has become Europe's No. 1 exporter of electric energy, with customers in the UK, Italy, and Switzerland.

France has 53 nuclear facilities and has relied heavily upon a standardized pressurized-water reactor implementation. This contributes to the reactors' reliability and helps reduce plant construction and maintenance costs [THE INSTITUTE, January, p. 1].

Intel's 32-gigaflops system

Intel Corp., Santa Clara, Calif., has received a US $15 million contract from the Supercomputing Consortium for a computer with a theoretical peak processing rate of about 32 billion floating-point operations a second.

The massively parallel machine will incorporate 528 of Intel's i860 microprocessors. The machine, called the Delta System, is to be applied to military work and to so-called scientific "grand challenges," including studies of global warming, visualization, and chemical reactions [THE INSTITUTE, January, p. 6].

Emissions goals for Japan

Calling on Japan to produce no more carbon dioxide in the year 2000 than in 1990, Japan's Environment Agency ran up against the powerful Ministry of International Trade and Industry (MITI). It contends that this ambitious goal is unrealistic, and instead urges a per capita freeze. This would allow an increase in total emissions of about 5 percent over the next 10 years.

But an action program, which runs until 2010, accepts either goal. The program also calls for emissions of methane to remain at the present level and for levels of nitrous oxide to remain steady "to the extent possible" [THE INSTITUTE, January, p. 1].

IBM and GM win awards

IBM Rochester (Minn.) and the Cadillac Motor Car Division of General Motors, Detroit, Mich., have won the 1990 Malcolm Baldrige National Quality Awards for manufacturing.

IBM's hard-disk and intermediate-computer operation in Rochester had a productivity increase of 30 percent between 1986 and 1989. Product development time has more than halved since 1983 and product reliability has tripled.

Cadillac's turnaround began in 1985 when the company started simultaneous engineering by multidisciplinary teams to define, engineer, market, and continuously improve Cadillac products.

Federal Express Corp. won the first Baldrige award in the service category, and Wallace Co. won as a small business [THE INSTITUTE, January, p. 3].

COMING IN SPECTRUM

U.S. air traffic control. A technological overview focuses on the latest safety measures being installed, the challenge to improve takeoff and landing delays, and the results reported for a new system developed by the IBM Corp.

Selecting a microcontroller. The software development tools that a design engineer has or plans to acquire will affect the process of microcontroller selection.

Spectral estimation with DSPs. Thanks to the availability of very high-speed digital signal processors and a new class of algorithms using parametric techniques, modern spectral estimating is proving practical and cost-effective.

Light rail comeback. Modern light rail transit systems use updated vehicle technology, separation of their tracks from other traffic, and innovative operating practices.

A high-speed CMOS technique. A pair of researchers at Sweden's Linköping University have taken a 3-micrometer CMOS process and attained clock frequencies in excess of 200 megahertz by exploiting clocking strategy, device sizing, and logic style selection.

Object-oriented databases. A second generation of object-oriented database management systems can meet the demands for both group data-sharing and interactive performance levels matching those of existing single-user applications.

Cutting the high costs of testing. A new modeling approach maximizes the tradeoffs associated with production testing of analog and mixed-signal devices. It is based on a simple linear coefficient matrix model that relates the device response to a set of underlying variables.

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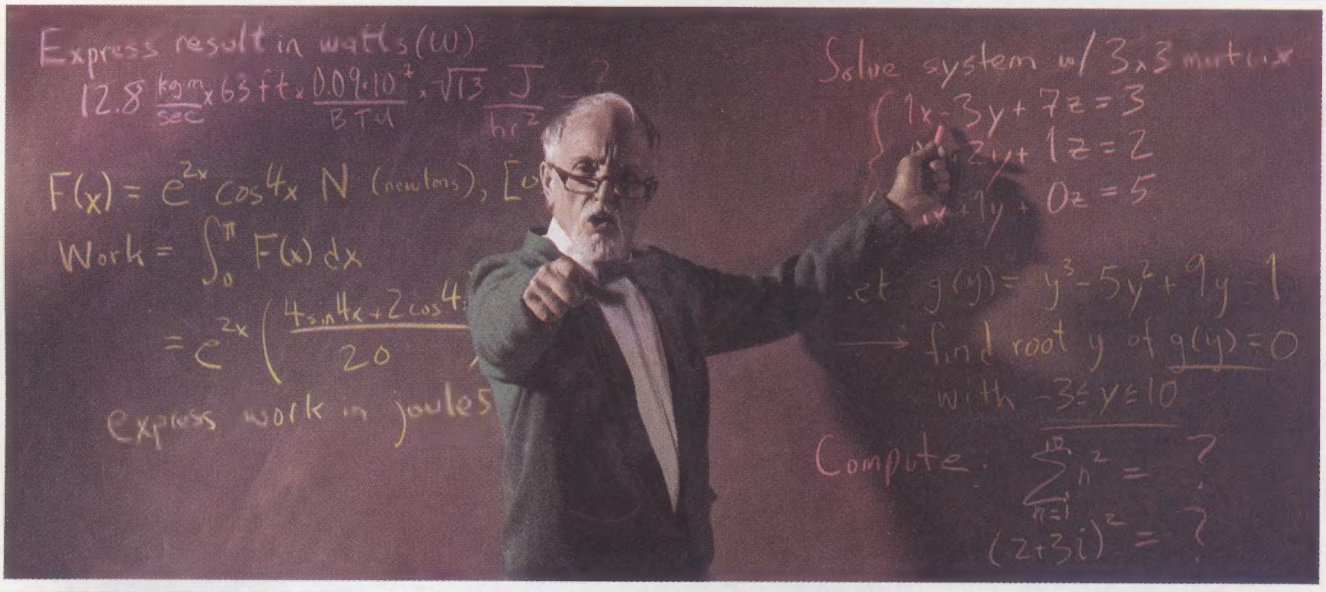
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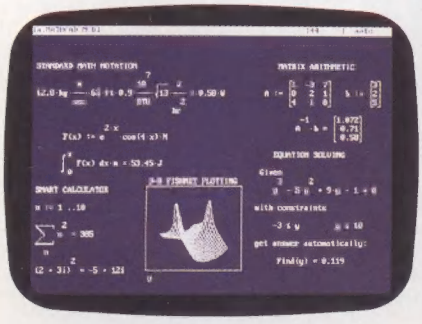


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